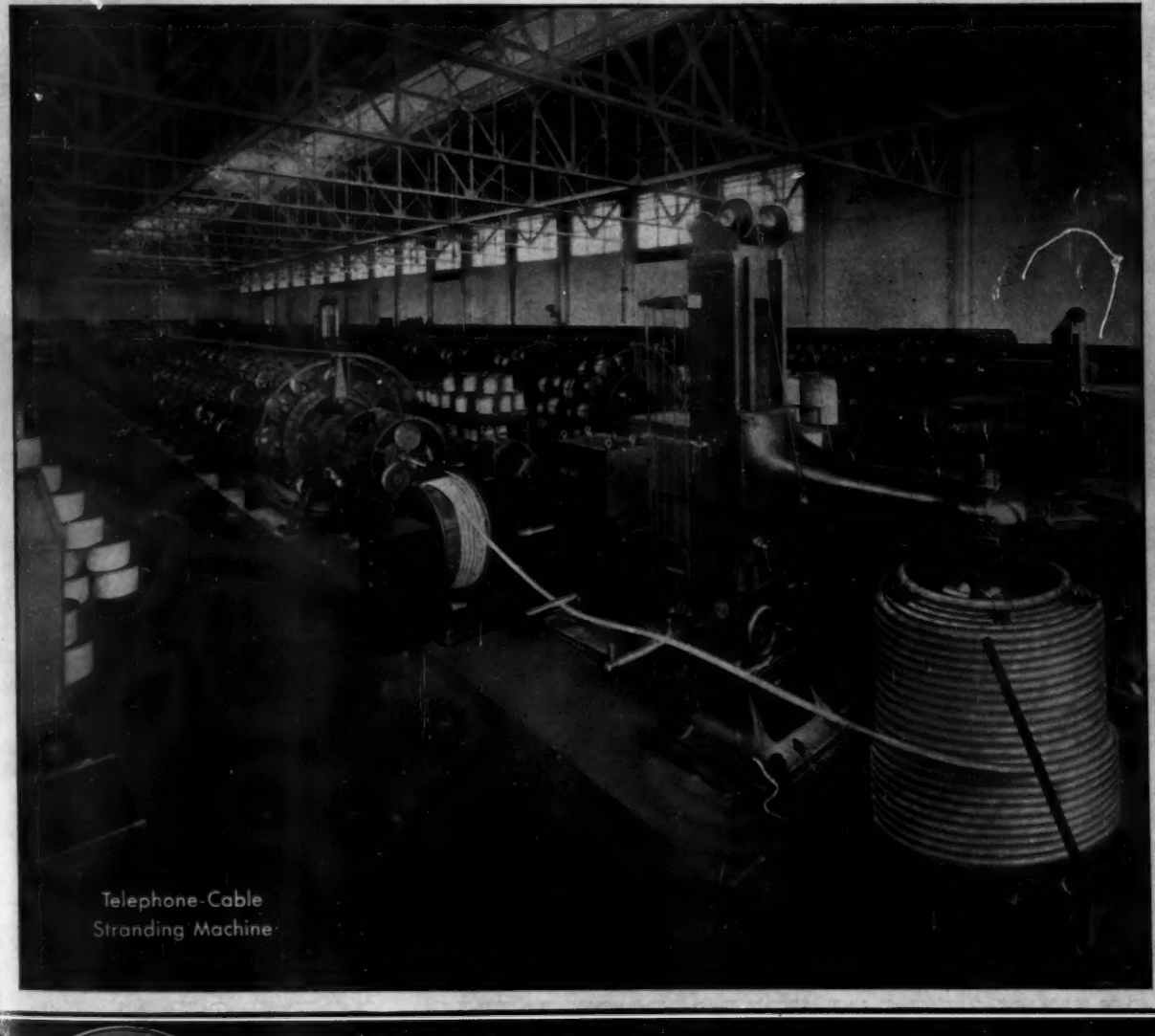
MAR 30 1931

# MECHANICAL ENGINEERING



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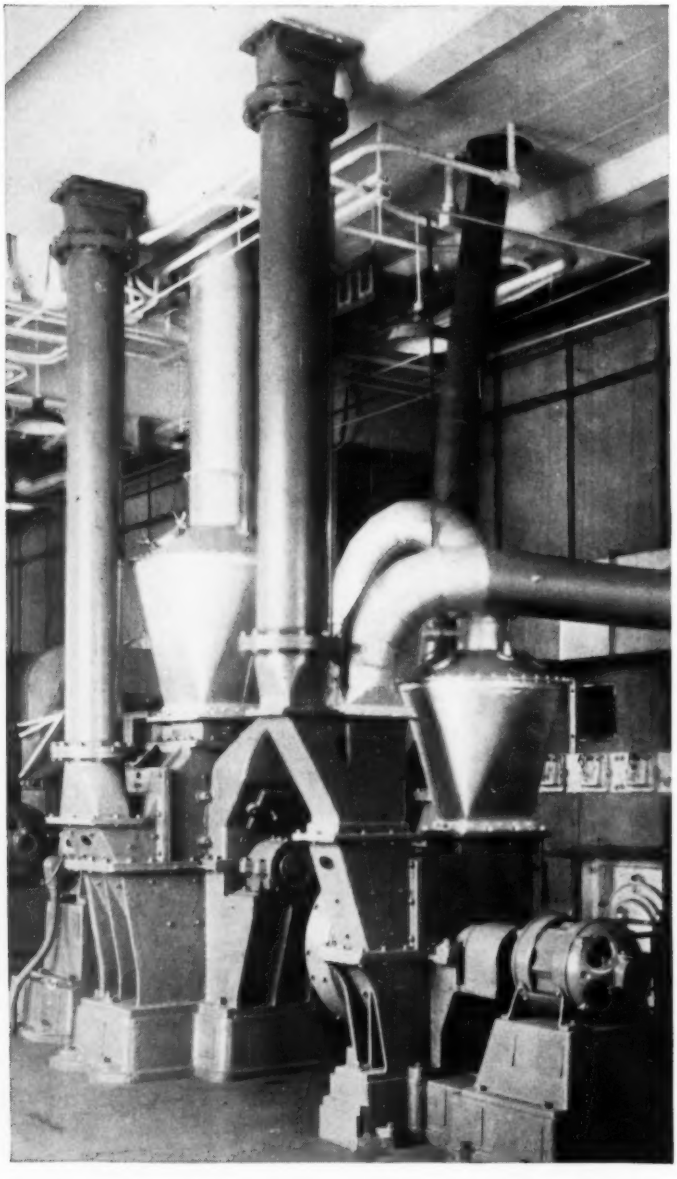

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# Mechanical Engineering

The Monthly Journal Published by
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# What It's All About

THE MECHANICS OF THE TELESCOPE provide one of those many opportunities for engineering skill to be of service to scientific research. Because astronomical telescopes are instruments of precision of enormous size, they present a wide variety of mechanical problems. In the April issue of MECHANICAL ENGINEERING, E. P. Burrell, designer of some of the world's most notable telescopes, describes the most common types used for astronomical research, and discusses such engineering features of their design as foundations, bearings, tube construction, the mirror and its support, driving clock, control mechanisms, and other accessories. While the field is a specialized one, engineers will recognize the fundamental nature of the design factors involved.

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PLASTICITY OF METALS brings us back from the unbelievable magnitude of the space that astronomers study to the microscopic particles crowded together in a piece of dense and apparently homogeneous metal. "Plasticity," writes Dr. Zay Jeffries, "is the quality by virtue of which a substance may undergo a permanent change in shape without rupture." Metals are crystalline, and plastic flow is the result of the movement of one position of a crystal with reference to another along crystallographic planes. Industrial metals are useful to us because of their high plasticity, without which metal-working processes could not be carried on.

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TRENDS IN STEAM-TURBINE DEVELOPMENT, as seen by A. G. Christie, are toward higher temperatures and pressures, increased capacities, and improved efficiencies. After discussing these features from the sound basis of contemporary progress, and touching on such other factors as the use of improved materials, the adjustment of turbines to specific services, and the more extensive development of binary-vapor cycles, Professor Christie hazards an estimate of the limiting performance to be expected of the steam turbine. This, he says, leads to a station heat rate of 9500 B.t.u. per kw-hr. of net output in a large plant with steam at 2500 lb. per sq. in. and 1000 deg. fahr., having two stages of reheating to the same temperature and six stages of bleeder heating.

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REVISION OF THE SKELETON STEAM TABLES at the Second International Steam-Table Conference, held last year at Berlin, Germany, is reported in this month's MECHANICAL ENGINEERING. The new values given supersede those of the 1929 report published in February, 1930.

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PREFERRED NUMBERS provide a basis for the standardization of sizes and dimensions. The series proposed for use in this country is discussed by R. E. Hellmund in the light of his attempts to introduce it into the electric manufacturing industry. He finds the decimal a handicap and proposes a supplementary fractional system to meet this objection. Technical difficulties, such as that of punching disks whose diameters are chosen as preferred numbers from sheets whose dimensions are also so determined, and the problem of the bolt and hole with clearance, are discussed. Such problems are not without hope of solution, and there are many cases where no such difficulties exist. Mr. Hellmund is convinced of the fundamental soundness of the preferred-number system.

:: :: ::

ENGINEERING OPPORTUNITY IN THE SOUTH, discussed this month by E. W. O'Brien, editor of the *Southern Power Journal*, is an appropriate subject in view of the coming Semi-Annual Meeting, Birmingham, Ala., April 20 to 23, of The American Society of Mechanical Engineers. Industrially the South is awake, competing in many lines with other parts of the country where manufacturing has long been an established tradition. Rich in natural resources of power and materials, and with an abundant labor market, the South offers an opportunity for engineering skill in the development of numerous industrial enterprises.

:: :: ::

THE MANUFACTURE OF LEAD-COVERED PAPER-INSULATED TELEPHONE CABLE is an important factor of an industry that is too modern to be stifled by traditional methods. The Western Electric Company revolutionized the drawing of copper wire, and has now developed some new processes in the manufacture of this wire into telephone cable. They are described by John R. Shea in this issue of MECHANICAL ENGINEERING. Wood-pulp insulation is applied directly to the wire without first being made into paper to be wound on. Cable stranding and vacuum-drying methods have been improved, and a new arrangement of the lead-covering plant provides for the centralized melting of the lead and its distribution through pipe to the sheathing presses.

MECHANICAL ENGINEERING

Volume 53 April, 1931 No. 4

# The Mechanics of the Telescope

## The Story of the Telescope From the Time of Galileo to the Present Day—The Various Mechanical Problems Encountered in the Design of a Modern Astronomical Telescope, and the Ways in Which They Have Been Solved

By E. P. BURRELL,[1] CLEVELAND, OHIO

IN ORDER to present a background for this subject, it seems desirable to sketch briefly the history of the telescope. The discovery of the telescope is a much-discussed question, the conclusion according to the "Encyclopedia Britannica" being that Hans Lippershey, a spectacle maker of Holland, was the first person who independently invented the telescope and at the same time made the instrument known to the world.

### History of the Telescope

Telescopes seem to have been made in Holland in considerable numbers soon after the date of their invention, and rapidly found their way over Europe. But the honors must be shared with the Italian philosopher Galileo, who in May, 1609, made his first telescope by fitting a convex lens in one extremity of a leaden tube and a concave lens in the other one. He presented the instrument itself to the doge Leonardo Donato, sitting in full council. The senate, in return, settled him for life in his lectureship at Padua and doubled his salary. Galileo may thus claim to have invented the telescope independently, but not until he had heard that others had done so. It is certain that he was the first to apply the principle of the telescope to astronomical research.

By the middle of the seventeenth century, several makers of lenses had so far improved the methods of grinding and polishing, that telescopes notably superior to that of Galileo were procurable. The Dutch philosopher Huygens developed telescopes varying in length from 150 to 200 ft. With one of these in 1655 he discovered the largest satellite of Saturn, thus adding a fifth member to the list of planetary bodies known to the ancients. But his most important astronomical discovery, made also in 1655, was the nature of the rings of Saturn.

To Sir Isaac Newton belongs credit for the discovery of the reflecting telescope. When in 1666 he made his discovery of the different refrangibility of light of different colors, he soon perceived that the faults of the refracting telescope were due much more to this cause than to the spherical figure of the lenses. Newton's first telescope so far realized his expectations that he could see with its aid the satellites of Jupiter and the horns of Venus. Encouraged by this success, he made a second telescope of $6^1/_3$ in. focal length, with a magnifying power of 38 diameters, which he presented to the Royal Society of London in December, 1671. A third form of reflecting telescope was devised in 1672 by Cassegrain. No further practical advance appears to have been made in the design or construction of the instrument until the year 1723, when John Hadley (best known as the inventor of the sextant) presented to the Royal Society a reflecting telescope of the Newtonian construction, with a metallic speculum of 6 in. aperture and $62^5/_8$ in. focal length, having eyepieces magnifying up to 230 diameters.

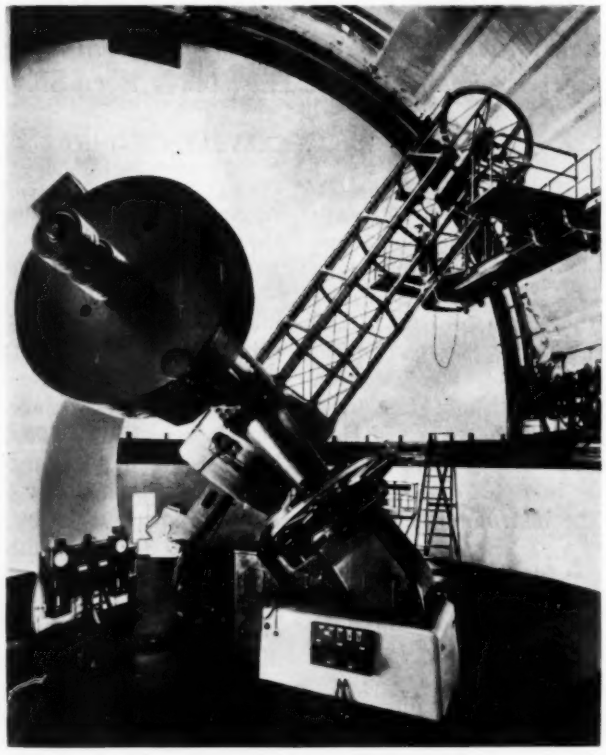
In 1755 the English optician John Dollond discovered that the dispersion of light was variable when refracted through different kinds of glass. With this fact as a key, he constructed object glasses having two lenses of such form and refracting power that one would correct the error of the other, and thus eliminate entirely the spherical aberration as well as the greater

[1] Director of Engineering, The Warner & Swasey Co. Mem. A.S.M.E. Mr. Burrell was graduated from Cornell University in 1898, receiving the degree of M.E. that year, and the degree of M.M.E. a year later. After a brief season with the Crehore-Squier Intelligence Transmission Co. he was engaged by The Warner & Swasey Co. as designing engineer in 1900, with which concern he has since been continuously connected, becoming successively works engineer in 1905, works manager in 1909, and director of engineering in 1924. He has personally directed the design of all large telescopes built by the company in the past twenty years, as well as range finders and other fire-control instruments for military use. Notable among the astronomical instruments are the 72-in. reflecting telescope for the Dominion Astrophysical Observatory, Victoria, B. C.; the 60-in. reflecting telescope for Ohio Wesleyan University and the 20-in. refractor for Chabot Observatory, Oakland, Calif. As a designer of machine tools he has contributed many important inventions, and is the holder of many patents in this field.

Presented before Section M (Engineering) of the American Association for the Advancement of Science at its annual meeting in Cleveland, Ohio, December 30, 1930.

part of the chromatic aberration. This invention removed in a very large measure the difficulty which for one hundred and fifty years had been a check to progress in the use of refracting telescopes. Credit is given to Chester Moore Hall, of Essex, England, for having made the first achromatic objective, in the year 1733; but the theoretical as well as the practical development of this great invention is certainly due to John Dollond.

About the year 1774 William Herschel, then a teacher of music in Bath, began to occupy his leisure hours with the construction of specula, and finally devoted himself entirely to their construction and use. In 1789 he completed his reflector of 4 ft. aperture and 40 ft. focal length. The reflecting telescope became the only available tool of the astronomer when great light grasp was requisite, as the difficulty of procuring disks of glass (especially of flint glass) of suitable purity and homogeneity limited the dimensions of the achromatic telescope.



72-IN. REFLECTING TELESCOPE, DOMINION ASTROPHYSICAL OBSERVATORY, VICTORIA, B. C.
(Designed and constructed by The Warner & Swasey Co.)

Each advance in the optical efficiency of the telescope necessitated equal improvement in mechanical means for adjusting and using the instrument. At first it was simply held in the hand, and even as crude methods of support came gradually into vogue, they were of small use other than for holding the tube approximately in position. Previous to the eighteenth century the best telescopes were used with the alt-azimuth mounting, having, as the name indicates, one motion in altitude and one in azimuth, the combination of these motions enabling the observer to point the instrument to any part of the visible heavens. The apparent motion of the stars made the use of this type of mounting very unsatisfactory and inadequate for observing, especially when high magnifying powers were required.

We do not seem to find any mention of the equatorial telescope until Roemer, the Astronomer Royal of Denmark, made one early in the eighteenth century, and we may believe he was the original inventor of this most excellent type of mounting which has become standard throughout the world.

Each generation has seen larger and still larger telescopes projected and finally built, as the development of the mechanic arts has made the greater enterprise practicable. This is naturally the case, for the astronomical telescope is essentially a mechanical device. It includes optical parts which must, of course, receive careful attention in their design and manufacture, for the usefulness of the instrument approaches a maximum only as its construction approaches both optical and mechanical perfection; but once the dimensions, weight, and relative position of the optical parts of the instrument are determined, the design of the mounting, or mechanical portion, may proceed to a large extent independently. It is therefore the purpose of this paper to invite attention to the great variety of mechanical problems that arise in connection with the design of an astronomical telescope.

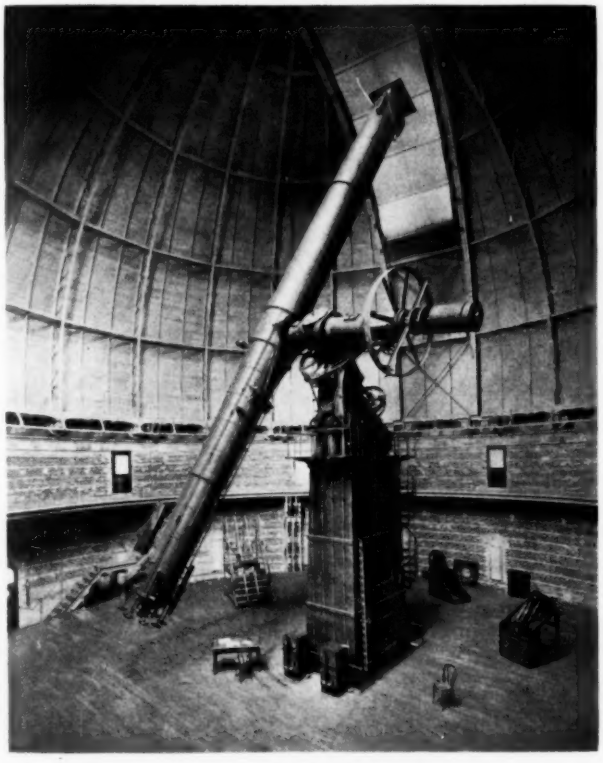
## TYPES OF TELESCOPE MOUNTING

While the principal features of telescope mountings are familiar, the equatorial mounting, sometimes referred to as the German type, will be first considered. The equatorial head, or portion which surmounts the heavy pier or column, carries the polar axis at an angle exactly equal to the latitude of the locality. Actually, then, the polar axis is parallel to the axis of rotation of the earth. At the upper end of the polar axis and at right angles to it, are bearings for carrying the declination axis. This axis in turn is rigidly fastened to the telescope tube at right angles to its optical axis. The combination of the two axes provides for universal movement of the telescope to virtually all points in the heavens. Accurate balance, so necessary to ease of operation and uniformity of motion of the telescope, is accomplished by carefully placed counterweights. Each axis is provided with graduated circles for easily reading the coordinates of stellar bodies as found in the tables giving star locations. The driving clock, which causes the tube to follow the apparent motion of the stars, is connected with the polar axis through a worm and wormwheel. Clamps make possible release of the wormwheel so that the tube may be directed to other heavenly bodies. Slow motions, either hand operated or mechanically operated, are provided for fine setting of the tube before employing the driving clock.

The equatorial mounting is by far the one most ex-

tensively used, most refracting telescopes and many reflecting telescopes having this type of mounting. Outstanding examples are the 36-in. Lick telescope and the 40-in. Yerkes telescope. In spite of the merits of this type of mounting, it has one outstanding disadvantage—the interference which occurs in attempting to observe a celestial body in the meridian north of the zenith. The eye end of the telescope tube comes in contact with the column, making it necessary to reverse the tube on the polar axis in order to continue the observation. In visual observations this disadvantage is not serious, but it does present particular difficulty in photographic observations.

Another form of mounting, sometimes called the English type, is similar to that just discussed, except that the two polar-axis bearings are placed on either side of the declination axis instead of both bearings below. This type requires two columns to support the polar axis, the north column usually being of considerable height. In order to provide clearance for the telescope tubes, these columns must be placed far apart, which in turn requires a long polar axis. This type of mounting is well adapted to reflecting telescopes, the best example being the 72-in. Dominion Astrophysical Observatory telescope.



40-IN. REFRACTING TELESCOPE, YERKES OBSERVATORY, WILLIAMS BAY, WIS.
(Designed and constructed by The Warner & Swasey Co.)

Another form, known as the "fork" type, is of much later development. It resembles the German type in respect to bearings for the polar axis, but is distinguished from it because the declination axis is replaced by trunnions which support the telescope tube at the upper end of the fork of the polar axis. This mounting is also well adapted to reflecting telescopes, the 60-in. reflector at Mount Wilson Observatory being the largest example so mounted.

A fourth form which somewhat resembles the English type is that employed on the 100-in. Hooker telescope at Mount Wilson Observatory. The polar axis in this mounting consists of a rectangular frame with a pivot bearing at each end. The telescope tube is mounted in this oblong frame on two declination trunnions. This mounting requires two columns or piers, the north column being higher for northern-hemisphere observatories. While this mounting has been used for both refractors and reflectors, it has the outstanding disadvantage of two restricted areas, while the other types above described have restricted areas in but a single location.

The Coudé mounting is ingenious and should be mentioned here. It resembles a partially inverted "T" in which the telescope tube utilizes half the cross-axis and nearly all of the polar axis. The object glass is located at the outer end of the cross-axis. The celestial body being observed is twice reflected to the observer's position at the upper end of the polar axis. The two telescopes in the Paris Observatory are the best examples of the Coudé mounting.

## FOUNDATIONS

One of the problems which is seldom understood is that having to do with telescope foundations. It is of prime importance that a telescope be as free as possible from vibration and that its footings be so constructed as to eliminate settling. The larger the mounting, the greater is the problem of its foundation. For installations near the ground, concrete or brick piers are successfully employed. It is always advisable to avoid high piers of small section, for they are subject to oscillation and the transmission of vibration from passing vehicles or distant railway trains. Refracting telescopes having 10-in. or 12-in. objectives have been successfully mounted upon buildings by the use of properly arranged and keyed structural-steel beams. These beams, while supported on the main walls of the building, must be free from the floors and entirely independent of the observing room.

In the case of large telescopes it is invariably necessary to employ massive foundations extending in some cases many feet into the ground. In the case of large reflectors of the English type, the piers often consist of hundreds of tons of reinforced concrete. Such piers resemble a massive "H" and extend from 45 to 50 ft. above the ground. They must be carefully designed to insure stability and minimum vibration.

## BEARINGS

Bearings used in mountings typify the progress of telescope engineering. In the earlier instruments only plain cylindrical bearings were used. While the speed of rotation is exceedingly low, it is nevertheless of

prime importance to reduce to the minimum the element of frictional resistance in order that uniformity of motion may be accomplished for the telescope tube. The use of the telescope for astronomical photography will readily indicate the importance of this feature. As the size of the telescope increased, the increased friction was relieved by a system of rolls and compensating levers frequently applied to the upper end of the polar axis. Mercury floats were also employed for the same purpose, sometimes in connection with these rollers. But with the development of anti-friction bearings of the ball and roller types, the difficulties theretofore encountered were almost completely overcome. In all examples of present-day medium-sized and large telescopes, anti-friction bearings are employed. When properly installed and packed with lubricant, these bearings will function with complete satisfaction for years.

The 72-in. reflecting telescope of the Dominion Astrophysical Observatory offers an excellent example of the reduction of friction by the use of modern bearings. The forty-five tons of movable parts are moved by a spring-scale pull of $3^1/_2$ lb. in right ascension and of $2^1/_2$ lb. in declination from the upper end of the telescope tube. The point of testing was 26 ft. distant from the bearings.

10-In. Bruce Photographic Telescope at Yerkes Observatory
(This is the instrument with which the late astronomer E. E. Barnard attained much fame.)

## The Polar Axis

The polar axis is really the backbone of the instrument. It carries the entire weight of the moving parts and, being inclined to the horizontal, presents the problem of thrust load in addition to that of deflection due to radial load, the latter being complicated by a continual change in the plane of deflection as the axis rotates. In the fork type of instrument the fork is really a continuation of the polar-axis structure, introducing into the design of that member not only the more or less indeterminate stresses and deflections of the fork itself, but also problems resulting from the concentration of almost the entire weight of the instrument on the bearing nearest the fork. Chief among these is the prevention of an excessive upward reaction at the other end of the axis. The divided-girder type of mounting escapes this disadvantage, but calls for careful design to avoid objectionable variations in deflection at different positions of the axis. The English mounting, or cross-axis type, has the advantage that the load is divided between two bearings and that the tube may be pointed in practically any direction. Whatever type is employed, it is essential that the effects of torque and flexure in the mounting be virtually eliminated.

In the German mounting the upper bearing of the polar axis is placed close to the declination sleeve and the bearings in the sleeve are located at points adjacent to their loadings, so that this design permits the employment of elements of sufficient size to reduce flexure to a minimum. This principle is followed in British and American designs, while German telescopes use a lighter construction, with a system of levers and counterweights to control deflection.

## Tube Construction

There is no more important element of the telescope than its tube. The function of this member is to support and hold in constant alignment the optical elements of the instrument. This function is the same in the case of both refractors and reflectors. For the refracting telescope the tube is usually constructed of sheet steel with a cast-iron section about midway in its length. It is to this cast section that the declination axis is bolted. The use of sheet steel permits the reduction in thickness of the sheets as they approach the ends of the tube. This practice assists materially in reducing the total weight of the tube. With this construction, the optical axis will maintain in the several positions of rotation a position practically parallel to the mechanical axis of the tube centerpiece. By the application of auxiliary apparatus such as cameras, spectrographs, etc., no difficulty will be encountered if the design of the tube provides sufficient strength. The problem is merely one of adding sufficient counterweights to the opposite end to maintain correct balance of the tube at all times.

In the large reflectors the problem is very different,

for the excessive weight of the mirror and its cell places the center of gravity close to the lower end of the tube. Here the mirror cell is attached directly to the centerpiece, which is either a great steel casting or is built up of structural-steel members. The remainder of the tube in the case of smaller reflecting telescopes is constructed of sheet metal, with diminishing thickness toward its upper end as already described. In the case of the larger telescope, some form of trussed or latticed construction is employed. In such tubes it is often possible to use to good advantage structural steel of commercial sizes; however, this does not permit the use of longitudinal members having a gradually decreasing section. Such members would be ideal if obtainable without prohibitive cost. This circumstance suggests the benefits to be derived from welding and the use of alloys lighter than steel. The conditions surrounding the telescope tube are in some respects similar to those encountered in aircraft design. It is within reason, therefore, to look forward to future designs which will employ modern welding similar to that now well established in the aircraft industry.

An important consideration in the design of the tube is the method of attaching secondary mirrors and other apparatus to the upper end, as it is necessary to arrange for three or more optical combinations. At least three methods are successfully employed. The large telescopes at Mount Wilson Observatory, as well as instruments in British and German observatories, have removable cages for these mirrors. These cages can be removed and replaced without getting the combinations out of adjustment. The weight of these cages requires the use of a crane for handling. A second method is that employed by the 72-in. Dominion Astrophysical telescope; here a centerpiece is attached to the tube structure at its upper end by four thin diaphragm plates. The secondary mirrors in their cells are then bolted to the bottom of the centerpiece. This system has the great advantage of reducing the weight factor of the removable elements; accordingly only a small hoist is required in lifting the parts. A third method employs a centerpiece mounting in the upper end of the tube, which is in general similar to that of the second method; the difference is in the size of the cylindrical hole in the centerpiece, which permits the passing of the mirrors in their cells through the centerpiece and then bolting them in place. This method permits a shorter overall length of tube, but the larger centerpiece obstructs a somewhat greater percentage of light to the main mirror.

Since the secondary mirrors are mounted directly in front of the main mirror, it is desirable to provide for supporting the secondaries so as to intercept the least possible light; at the same time the centerpiece-support construction should permit the passage of the cone of light to the prime focus whenever that position is to be used. Accordingly the method which obstructs the minimum amount of light in all cases is that preferred.

In recent large reflecting telescopes provision has been made for a protecting cover for the main mirror as an insurance against damage and changes in temperature. A successful type of cover is the triangular-leaved shutter, hinged to fold inward a few inches above the mirror surface.

## Mirror Cell and Supports

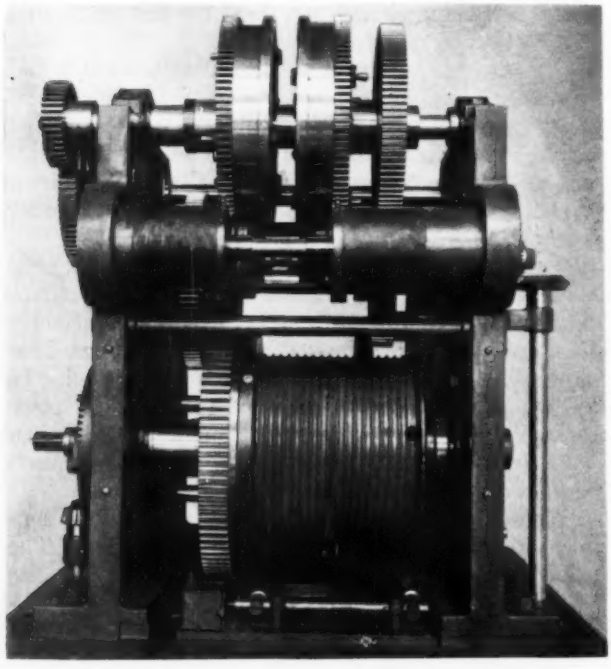
Few scientists, other than those directly associated with the operation of telescopes, realize the importance of that element of a large reflector which holds in position the great mirror. Were the mirror to remain in a fixed position with reference to the zenith, there would be but one condition with which to contend, i.e., properly supporting its weight. But in actual use the telescope tube traverses all parts of the heavens, and in so doing the mirror in its cell at the lower end of the tube takes every angle between the horizontal and the perpendicular. Accordingly it is essential that the mirror be at all times supported so that whatever position the telescope tube may take, the mirror will still be in correct optical relation with the center line of the tube.

The mirror cell usually takes the form of a pan, deep enough to permit free circulation of air round the mirror to equalize the temperature. It must be sufficiently rigid to afford proper support for the mirror regardless of the direction in which the tube is pointed. In addition, the cell may be required to provide a place for attaching a spectrograph or similar device, often of considerable weight, and yet must be readily removable to permit access to the mirror for resilvering.

A system of pads or pans has been successfully employed for the bottom support of the mirror. The number and size of these pads depend upon the size of the mirror and the area of the sector to be supported. For correct collimation it has been found that the principle of three-point support is imperative; the number of the supports being in all cases divisible by three. A common method used, both in this country and abroad, consists of beam arms carried by three collimating screws which in turn support single, double, or triple groupings of pads. The connection at each point is a spherical bearing, located at the center of gravity of the member being carried. This system insures an automatic and even distribution of the weight, and if properly designed the amount of flexure in all elements is uniform. It is interesting to note that at the meeting of the A.A.A.S. at Albany, in 1851, Josiah Lyman exhibited a $9^1/_2$-in. speculum with an ingenious system of supporting levers.

In the case of very large and heavy mirrors, it is essential to provide a system of supports in which the individual pans are counterpoised and supporting fulcrums are attached directly to the framework of the mirror cell. In this system also each element must have the support at the center of gravity of its sector. This arrangement releases the collimating screws so that they carry only their proportion of the load. A mirror must also be adequately supported on its edge in order to reduce to the minimum its tendency

to sag when in a nearly horizontal position. A successful method for accomplishing this includes two solid and two spring sectors equally spaced, the latter also constructed so as to avoid gripping and at the same time prevent movement of the mirror. In some of the German telescopes zinc blocks are inserted between the mirror and its cell to compensate for difference in expansion. In the case of the two largest American mirrors there are cork-lined rings surrounding their edges, and these are counterpoised at twelve equally spaced positions. The cork-lined ring is held in fixed position by two solid and two spring sectors, using knife-edge contact located in the plane of the center of mass of the mirror.



Driving Clock of the 72-In. Reflecting Telescope at the Dominion Astrophysical Observatory
Showing weight-driving drum and above it the solenoids and differential gearing for "setting" and "following" motions.)

## The Driving Clock

There is no more accurate element of a telescope than its driving clock—that mechanism which causes the tube to move as the stars progress across the heavens. The perfect balance of the tube serves to greatly lessen the task of the driving clock by making its load uniform regardless of the angle at which the tube may be pointed.

It was in 1825 that Joseph Fraunhofer, the eminent physicist of Munich, invented the driving clock. This was a great advance in telescope history, for it made possible accurate observations covering long intervals.

The driving clock used in nearly all the observatories in this country is constructed with a double conical pendulum mounted isochronously—that is, the speed of revolution is independent of the position of the balls within certain limits. This permits the adjustment of the pendulum so as to compensate for a considerable variation of driving torque, with only a momentary, and hence imperceptible, deviation from a given speed. The driving power is furnished by a weight system connected to the gear train so that hand or motor winding does not affect the torque.

Since atmospheric refraction causes an apparent variation in the motion of the stars, it is necessary to provide means for retarding and for accelerating the slow motions in right ascension. These are frequently referred to as "setting motions" (for centering the image) and "following motions" (for maintaining the image as required). This has been successfully accomplished by a double planetary differential mechanism so located in the driving gear train that when placed in operation it adds to or subtracts from the normal speed of the driving worm.

The drive from the clock to the polar axis of the instrument is by means of an accurate worm and wormwheel. The wormwheel is mounted with anti-friction thrust and radial bearings on the axis, and is clutched to it as required by the operator. A wormwheel 9 ft. in diameter and of two tons weight can be kept in motion by a pull of $^1/_2$ lb. at its rim. In some cases the differential train has been omitted and replaced by a motor and a system of gearing between the clock and the driving shaft. This system is used to obtain various speeds for following.

Clocks of this construction have been used on the largest telescopes in the world, and in some cases for more than forty years with entire satisfaction. There is an English clock having a motor-driven weight system with centrifugal governor, controlled by rubbing pieces on an adjustable contact ring. Its drive then passes through two double sets of planetary differential gearing, one set used to correct the governor speed by means of an automatic control from an observatory pendulum, while the other is used for manual following.

Probably the German clock having the most extensive application is one in which springs oppose the centrifugal action of the pendulums, while the resisting friction is obtained from a contact ring. The driving force is obtained through a motor-driven weight control system. The speed of the governor is rectified through a differential controlled by an observatory pendulum.

"Slow motion" is the term applied in telescope engineering to indicate the slow speed of advance of the telescope tube in setting. There are slow motions in both coordinates. It usually means the speed which brings the star to the center of the field of view immediately after clamping the driving mechanism. In small telescopes all such motions, both fast and slow, are accomplished by hand, but in the larger mountings motorized controls are necessary.

The declination slow motion is obtained from an electric motor attached to a system of reduction gearing, magnetic or solenoid-operated clutches being used to select the desired combination and to control the direc-

tion of rotation. Thus the means is provided for rotating a worm at the desired speed for moving a worm-wheel or sector which is keyed or clamped to the declination axis. The slow following motion of the clock is from $^3/_8$ to $^1/_2$ minute of arc to a minute of time, and the setting motion is from $7^1/_2$ to 12 minutes.

Quick motions in both right ascension and in declination are essential for speed of the telescope from one celestial object to another. Quick motion is, of course, employed in advance of the slow motion just described. Quick motions are obtained through spur, spiral, or worm gearing, depending upon the design, a large spur gear keyed to the axis and driven through a pinion clutched to a system of motor-driven reduction gearing being the usual arrangement. An interlocking system of clutches is necessary in this case so as to keep the instrument in control at all times, and it is desirable to have one set of these clutches spring operated so that should the electrical power fail or be thrown off at any time, the mounting will be locked in position and accidents avoided.

The rate of motion for quick setting varies with the size of the instrument. A 36-in. reflector could probably be turned a complete rotation in three minutes, while our large mountings can be moved about 45 degrees per minute of time.

## Electric Control

Smaller mountings use electricity only as a means of illuminating the circles and the micrometer cross-wires, and in connecting and operating some accessories such as the chronograph. The application in the larger instruments is quite extensive and must also include the control of the dome and its various elements. For larger installations, master switches must be located at some convenient place from which the right ascension and hour circles can be easily observed. These switches control the setting of the telescope in quick motion, the release and proper clamping by the necessary clutches, and also the rotation of the dome and opening of it shutters.

Solenoids, or magnetic coils, are used extensively in the mountings as a means of operating elements where remote control is necessary. Examples of these are the actuating of the slow and setting motions of the clock, various clutches, and their interlocking systems of safety devices. Motors ranging in size from $^1/_{20}$ to 10 hp. have various applications, such as operating minor protecting shutters, focusing secondary mirrors, and quick and slow controls. The dome also requires motors for turning, opening, and closing the large shutters, operating the upper and lower wind curtains, and, in the case of large reflectors, the observing platforms. In some cases motors are also required for elevating floors, observing chairs, various cranes, and hoisting apparatus.

The observer's control of the telescope is usually obtained through various push-button switches contained in some form of light, portable box, which can be either hooked on to the instrument or the observer's belt; this is connected by means of flexible cables directly to the operating elements or the switchboard. The main switchboard for a large mounting carries various forms of special apparatus aside from those of standard construction, requiring possibly 50 sq. ft. of panel surface, the installation using upward of three miles of wire.

## Accessories

Many other features could be discussed if time would permit; such as three-prism spectrographs and their collimating devices and cameras, protecting and diaphragm shutters for the large mirrors; also many other devices and the methods of handling them; the apparatus required for silvering the large mirrors; elevating floors required for large refractors, and observing bridges for large reflectors, domes, shutters, and wind curtains. All these enter into the problem of a large observatory, aside from the design of the actual building.

MECHANISM CONTAINED IN THE DECLINATION HOUSING OF THE 72-IN. DOMINION ASTROPHYSICAL TELESCOPE

## Conclusions

It seems evident that the difficulty in obtaining larger refractor lenses indicates that the developments in the near future may be along the line of reflectors. The future development of the reflector will depend largely upon optical science, for the mechanical problems of larger mountings are, for the most part, all capable of solution. Even though advance in the development of our instruments has placed America in a corresponding position in the field of scientific accomplishment, our hopes and ambitions can well be directed toward larger instruments in that we may learn more of the limitless universe of which our earth forms a miniature part.

# On the Plasticity of Metals

## High Plasticity Largely Responsible for Widespread Use of Industrial Metals—Most Favorable Arrangement of Atoms for Slip Movement—Small Loads Required to Permanently Deform Single Crystals—PossibilityThat Free Electrons Are Essential for Metallic Plasticity

By ZAY JEFFRIES,[1] CLEVELAND, OHIO

PLASTICITY is the quality by virtue of which a substance may undergo a permanent change in shape without rupture. In many non-metallic plastic materials the flow is essentially fluid. Plastic clay, for example, consists of particles which are or may be non-plastic, surrounded by a liquid. During deformation the solid particles move bodily and the liquid conforms to the new shape. The mechanism of the plastic deformation of metals is, however, quite different. Metals are crystalline, and plastic flow is the result of block movement of one portion of a crystal with reference to another, the movement being along crystallographic planes. Although a number of non-metallic crystalline substances possess this characteristic to some extent, the metals are in a class by themselves in this respect.

The high plasticity of most industrial metals is perhaps more responsible than any other quality for their widespread use. It is an essential property in the application of many metallic products, and a necessary one in all metal-working processes. Furthermore, since hardness is measured by resistance to plastic deformation, and since methods or treatments designed to change hardness constitute a large part of the metal art, plasticity assumes a major rôle on the metallurgical stage.

### Most Commercial Metals Polycrystalline

During the past thirty years there has been great activity in various parts of the world in the further study of plasticity. During the first twenty years of this period the studies were largely carried out with polycrystalline metals, and the X-ray was for the greater part of the period not available as a tool to assist in the interpretation of results. The studies were characterized by the ingenious use of the microscope and the use of almost every available physical and chemical test. During the last ten years methods for the preparation of single crystals of various metals of sufficient size and proper shape for tensile tests and the use of X-ray crystal analysis have enormously stimulated the further study of the mechanism of plastic deformation.

Nearly all commercial metals are polycrystalline. Variation in grain size is a most important factor in connection with plasticity. Grain shape and grain orientation are also important factors. It would seem that these variations would have been sufficient to baffle the metal workers of the past, but of necessity they had to cope with the added difficulties resulting from alloying. The scientific studies of plasticity are so involved that the present discussion will be confined largely to single-phase metals.

### Plastic Deformation of Single Crystals

The study of the plastic deformation of single crystals of various metals and X-ray crystal analysis have greatly enriched our knowledge during the last fifteen years. Hull pointed out that most of the pure metals crystallize with simple space lattices. Face-centered cubic, body-centered cubic, and hexagonal lattices are most common. The face-centered cubic lattice (Fig. 1) represents the most favorable arrangement of atoms for slip movement, and the most favorable families of planes are those of greatest atomic density, namely, the [111] and [100] planes In the body-centered cubic lattice (Fig. 2) the [110] planes should be most favorable for slip. There has been some question as to whether the [110] or the [112] planes in iron, as an example of a body-centered cubic lattice, are the planes on which slip actually takes place. Most of the results are consistent with the idea that slip is usually on the [110] planes, and at times conjugate [110] planes may cooperate to produce slip which appears to be on [112] planes. This point is, however, too involved to expound in the present discussion. In the hexagonal system the basal plane, that is, the base of the unit hexagon, is usually the one most readily permitting slip.

Not only does slip prefer certain families of planes, but there are also preferred directions of slip along any given plane. The planes and directions can be deduced with surprising accuracy by considering the atoms as solid spheres. The preferred directions correspond

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to the V-grooves in a layer of tightly packed spheres.

Now comes another surprise. If the grains of a fine-grained metal are at the outset randomly oriented, continued working in one direction, as by strip rolling, will tend to change the fragments resulting from slip toward the same orientation. This is referred to as "preferred orientation." Different methods of working yield different results as regards preferred orientation. Still another complication arises in some metals which form mechanical twins during the course of plastic deformation. Mathewson has greatly enlightened us on this subject, his main contribution being "Twinning in Metals," published by the American Institute of Mining and Metallurgical Engineers, Institute of Metals Division, 1928. One interesting observation with respect to twinning is that most of the actual deformation takes place by slip movement the same as in metals which form no twins. The twinning is helpful in changing the orientation of the crystals in such a manner as to facilitate slip. Also, twinning has an important influence on the orientation of the grains after recrystallization. Mathewson, in coarse-grained zinc which had been alternately worked and recrystallized, has been able to find, by X-ray analysis, the "generations" of twins corresponding to each cycle.

## Preferred Orientation Common in Industrial Wrought Metals

Inasmuch as most commercial metal-working operations effect considerable elongation in one direction, preferred orientation is common in industrial wrought metals. It is not suggested that preferred orientation impairs the utility, but it seems clear that for some purposes it is not desirable. On the other hand, preferred orientation in drawn tungsten wire seems to be a decided advantage in controlling the orientation of the recrystallized grains in lamp filaments. Iron and steel have enjoyed a sort of fortuitous immunity from either the good or bad effects of preferred orientation, at least with respect to many commercial products, like structural steel and rails. Working is carried on above the upper critical temperature while the iron is in the gamma or face-centered cubic phase. Preferred orientation of the gamma grains no doubt obtains, but on cooling through the critical range the gamma iron changes to alpha or body-centered cubic iron and new grains form with approximately random orientation. Alpha iron which has been extensively worked below the critical temperature also develops preferred orientation. This is eliminated by annealing above the critical temperature. With the advent of the nickel stainless steels which retain the gamma phase at both high and low temperatures, and silicon transformer steel, as well as certain high-chromium rustless irons which retain the body-centered cubic structure hot and cold, the steel-working art faces a problem in orientation control. The same problem exists in the working of non-ferrous metals. Whether preferred orientation of grain fragments resulting from plastic deformation is desirable or otherwise, it is clear that it must, for special purposes at least, be put under control.

## Types of Fracture of Single Crystals

Surprises were also plentiful in connection with the types of fractures resulting from tensile tests of single crystals. The wedge fracture is a typical one in metals

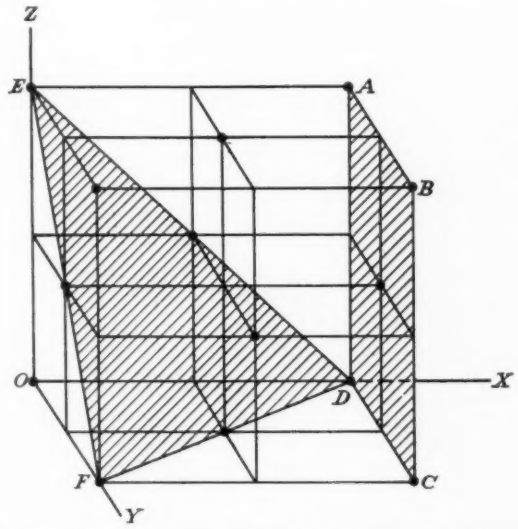


FIG. 1 FACE-CENTERED CUBIC ARRANGEMENT OF ATOMS

(The intercepts of any plane on the axes of reference *OX*, *OY*, *OZ*, are its parameters, one of which is taken as unity. Thus, for plane *ABCD* the parameters are 1, ∞, and ∞. The "indices" of a plane are the reciprocals of its parameters, and for plane *ABCD* are 1, 0, and 0, writen as [100]. For plane *EFD*, called the "ground plane," the parameters are 1, 1, 1, and the indices 1, 1, 1, or [111].)

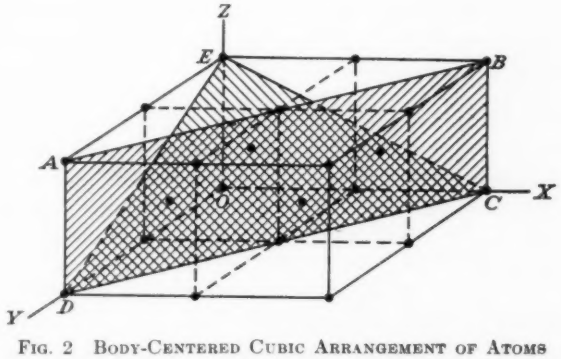


FIG. 2 BODY-CENTERED CUBIC ARRANGEMENT OF ATOMS

(Four unit cells are shown. *ABCD* is one of the [110] planes in this lattice, and *EDC* one of the [112] planes. See note under caption of Fig. 1.)

crystallizing in the cubic system. The orientation must be proper and two sets of intersecting slip planes of the same family cooperate to form the wedge. In one direction there is practically 100 per cent reduction of diameter, and 90 deg. from this direction the diameter remains substantially unchanged. Other orientations give rise to a great variety of interesting fractures. In hexagonal metals there is a tendency for an original round section to flatten first into an elliptical cross-section, and if elongation prior to rupture is considerable, the final shape resembles a flat strip having a width approximately equal to the original diameter of the test piece. Again there may be an abrupt change in the

shape of the cross-section as the result of mechanical twinning.

The extent of movement on a slip plane may be anything from a small fraction of an atom diameter up to more than five thousand atom diameters. The smaller movements may only be detectable by some change in property, but the larger slips can readily be seen with a microscope. If a section of the metal is polished before deformation, the slip movement may produce a difference in level between the portions of the crystal on either side, thus facilitating detection with the microscope. Slip in many plastic metals has been studied in this manner. In some cases the slip lines are very straight, and in others, irregular. Some crystals show one predominating direction of movement, and others exhibit sets of intersecting slips. Particularly in single-crystal wires there is a tendency for the visible slip planes, or slip bands, as they are called, to be evenly spaced. Some observers have reported that the spacing tends to be farther apart the higher the temperature of test for any given metal. The deformation does not proceed in a continuous manner, but actually takes place in steps or jumps. Some single crystals and coarse-grained metals give out sound, known as a "cry," during deformation. This seems to be associated with the formation of mechanical twins. This suggests an internal shock when certain of the atoms make the slight shift necessary for twinning. Apparently external shock favors mechanical twinning, because alpha iron which forms no twins on slow loading will do so on impact. Another surprise may be noted in this connection. Rosenhain found that if a piece of alpha iron is deformed even a small amount by slow loading and if then the deformation is continued by impact, no mechanical twins form.

## Small Loads Required to Fracture Single Crystals

Perhaps some of the greatest surprises in the study of the plasticity of single crystals of metals have been the unexpectedly small loads required to permanently deform them. It is not difficult to cold-draw copper wire until it has a tensile strength above 50,000 lb. per sq. in. In this condition there may be very little permanent extension in bringing the load up to this value. However, a single crystal of copper three-quarters of an inch in diameter and long enough for a grip can be bent without difficulty in the two hands. Hardening accompanying this deformation can be easily detected because greater force is required to straighten than to make the original bend, and a second bending is still more difficult.

It may be of interest to mention that tungsten filaments approaching single-crystal structure are in general use because of their non-sag characteristics. At the relatively high operating temperature fine-grained filaments sag gradually as a result of their own weight. This general phenomenon, referred to as "creep," is the subject of much study at the present time in connection with metals and alloys for use at elevated temperatures. In fine-grained tungsten filaments the gradual sagging has been traced to a sort of fluid flow at grain boundaries. The grain boundaries behave as if they were amorphous. Naturally a grain-boundary displacement will force some kind of readjustment on the crystals themselves, and this may take the form of slip or transfer of atoms from one grain to another.

## Rate of Loading an Important Factor

The rate of loading is an important factor in determining the extent and nature of plastic deformation in hot metals. Coarse-grained tungsten will resist sagging for hundreds of hours, but will deform if the lamp is bumped. A fine-grained filament which sags badly in the course of time will resist deformation by bumping. These factors are now very well understood, and the structure of filaments and methods of mounting are controlled to provide resistance against both slow and rapid loading.

Studies of tungsten filaments have provided some useful information. It was observed years ago that hairpin-shaped filaments mounted horizontally had about equal resistance to permanent deformation at 1350 deg. cent. no matter whether coarse- or fine-grained. Above this temperature the coarse-grained metal was superior, and below it the fine-grained metal was best. The change in the sag resistance of single-crystal tungsten was not great with increase in temperature. A filament which would not sag at 2000 deg. cent. would not sag at, say, 2500 deg. cent. In fact, the single crystal seemed to retain a definite but small elastic limit nearly up to the melting point. There seemed to be little change in the elastic limit down to, say, 1600 deg. cent. We observe here the same characteristic as that just described for single-crystal copper. It is not conceivable that the single crystal of copper which had an elastic limit approaching zero at room temperature could have had an appreciably lower elastic limit at, say, 1000 deg. cent. or some 80 deg. below its melting point. This same characteristic has now been observed in several other metals.

Realizing the extreme softness of single crystals of metals and the very slight change in hardness with change in temperature (at least within certain temperature limits), it now seems remarkable that the mere aggregation of differently oriented single crystals can result in the properties of polycrystalline metals. The change in orientation alone does not seem adequate to account for all of the results. Fine-grained metals not only possess markedly greater elastic limits and tensile strengths than the constituent crystals, but the properties vary with change of temperature in a different manner. For example, Sykes found that a molybdenum wire composed of a series of single crystals had the same tensile strength (30,000 lb. per sq. in.) in the temperature range 100 to 900 deg. cent., whereas a fine-grained molybdenum wire had its strength reduced from 115,000 lb. per sq. in. when tested at 100 deg. cent. to 70,000 lb. per sq. in. at 900 deg. cent. This discrepancy is still greater in molybdenum which has been

worked below its recrystallization temperature and which in many respects simulates a very fine-grained condition.

The grain-boundary effect is by no means confined to the boundaries themselves. This is illustrated nicely in Sykes's experiments on molybdenum wires consisting of a series of crystals each of which occupied the whole cross-section for a short distance. During the tensile test the grain-boundary portions remained undeformed and the crystals necked down, the greatest reduction of area being nearly halfway between grain boundaries. This result is explainable on the ground that a change of orientation at the grain boundaries militates against the continuity of slip movement from one grain to another, but this simple interpretation does not negative the fact that fracture takes place as far from the grain boundary as it can, even though the distance be hundreds of thousands of atom diameters.

Another observation on single crystals of tungsten and molybdenum is that the elastic limit, which, as has been mentioned above, does not change much from the melting point down to relatively low temperatures, rises very rapidly on reaching a certain low temperature. A single crystal of tungsten can be bent at room temperature, but in liquid air the elastic limit is enormously increased and fracture occurs without any noticeable permanent deformation. Similarly, coarse-grained molybdenum more than trebles its tensile strength and the elastic limit is increased to an even greater extent on cooling from 100 deg. cent. to —190 deg. cent.

## The Wonderful Nature of Plasticity in Metals

The more we study plasticity in metals the more wonderful does its nature appear. Hull attributed the brittle nature of crystals of non-metallic materials to the ionic nature of the atoms. In sodium chloride, for example, the sodium is supposed to be present as positive, and chlorine as negative, ions. On slipping one atom diameter, positive ions are brought opposite other positive ions and negative ions opposite other negative ions, with resultant repulsive forces and cleavage. There are supposed to be no or very few free electrons in non-metallic substances. Metals are supposed to contain free electrons. How many free electrons, what their positions or movements are, or in what manner if any they contribute to plasticity, are questions which are as yet unanswered. Physicists are doing a large amount of work in an effort to explain metallic conduction of electricity. Any progress which they make will prove helpful in the interpretation of plasticity. So far two extremes of electron arrangement have been proposed. The so-called classical theory assumes the free electrons present as a perfect gas, and Lindeman has suggested the presence of free electrons at space-lattice points different from the atom-lattice points. The electron space lattice is supposed to be related to the atom space lattice. Also the idea that electrons simulate waves is being considered to explain metallic conductivity. Any of these conceptions can be used to account for the very low elastic limits of single crystals if we assume that the free electrons expand the atom space lattice.

Let us digress a moment to consider this point in more detail. Although high electric conductivity and high crystal plasticity are the common attributes of metals, it is clear that the two properties do not vary in the same way and not necessarily in the same direction. It may be more than a coincidence that the best conductors of electricity have face-centered cubic crystals, which is also the most plastic type of crystal. A single crystal of tungsten has higher electric conductivity in liquid air than at room temperature, but completely loses its plasticity at the lower temperature. Intermetallic compounds are good electrical conductors, but they may be non-plastic. Also, single crystals of intermetallic compounds may exhibit an extreme resistance to slip movement. Tungsten carbide, for example, is as hard as emery. Such facts would lead us to suppose that there is little relation between free electrons and plasticity.

## Possibility That Free Electrons Are Essential for Metallic Plasticity

The noble gas argon solidifies at —188 deg. cent. with a face-centered cubic space lattice. It is monatomic, and the atoms should not be present in the space lattice as ions. It is transparent and practically a non-conductor of electricity. It would thus appear to have all of the requirements for high plasticity, unless free electrons are important. A few years ago the author tested solid crystalline argon for plasticity and found it to be brittle. It behaves like most non-metallic crystals. While this does not prove that free electrons are essential for metallic plasticity, to his mind it strongly suggests some relationship.

Whether we like a mechanistic conception of atoms or not, they seem to behave in plastic deformation as if they are somewhat like solid spheres or similar shapes. May we not suppose that the atoms of argon in its crystal are so close together that slip movement cannot take place without increasing the distance between planes? In other words, the high spots of the atoms on one plane so closely fit the recessions in groups of atoms of adjoining planes that slip is prevented. If we assume that free electrons in a metal are provided by neutral atoms, some or all of the atoms, depending on the number of free electrons, must be positively charged. This would provide one force tending to hold the atoms apart. The normal place for a free electron with its negative charge would be as far away as possible from other free electrons and between positively charged atoms. There is thus some reason to expect free electrons to increase the distances between atomic planes, and there is reason to expect such increase to account not only for the great plasticity of metals but also for some of the peculiar observations with reference to temperature effects.

Taking single crystals of tungsten as an illustration, we can visualize the important potential slip planes so

far apart just below the melting point that the atoms on one plane do not engage those on adjacent planes, with consequent low resistance to slip. As contraction occurs on cooling, a temperature is finally reached at which the atoms approach the condition described for argon, and plastically the crystal behaves much like argon. Of course, the high attractive forces resulting in a high melting point must have a potent influence on the low-temperature resistance to deformation and rupture. This is only one of many factors, however, which will require evaluation for the clarification of this subject.

### Face-Centered Cubic Metals Retain Plasticity at Very Low Temperatures

The type of space lattice is apparently very important. Face-centered cubic metals, as for example, gold, silver, copper, lead, and aluminum, retain plasticity at very low temperatures, that is, below —190 deg. cent. Face-centered cubic iron retains plasticity at low temperatures better than body-centered cubic iron. In general, the body-centered cubic metals do not retain low-temperature plasticity as well as face-centered metals. Hexagonal rhombohedral metals like bismuth and antimony become brittle at temperatures not far below their freezing points. The author tested fine-grained and coarse-grained commercial wrought zinc in liquid air a few years ago and found no plasticity. He concluded that the hexagonal space lattice was not conducive to retention of plasticity at low temperatures. In attempting to gain additional evidence on this point, he tested a piece of commercial magnesium wire and was rewarded with another surprise: he found it quite bendable at —190 deg. cent. Mankind may have cause to rejoice in the future because the two metals, aluminum and magnesium, which have most favorable densities for aircraft use, can endure the low temperatures encountered at high altitudes without becoming brittle.

It might now be concluded that the light-weight atoms have some claim to superiority in the maintenance of low-temperature plasticity. To spoil this idea as having any claim to generality, it is now found that beryllium, having a lighter atom than magnesium, becomes substantially non-plastic well above room temperature.

The author wishes now to describe his last two surprises. Dr. Schmid of Germany about two months ago gave him some single crystals of pure magnesium in wire form. Each crystal was about six inches long and three-thirty-seconds of an inch in diameter. The first surprise was in learning of the minute effort required to bend one of these specimens. The elastic limit is so low as to be hardly measurable. By holding one end of a specimen a bend can easily be made by a gentle flip of the wrist. The author was not prepared to find such a soft state in magnesium, notwithstanding experience with single crystals of many other metals. His last surprise came a few days ago when one of these magnesium single crystals was cooled to —190 deg. cent. in liquid air. It remained so soft that it could be bent with scarcely any effort. The elastic limit was so low that no substantial difference between the —190-deg. cent. and room-temperature values could be detected without fine measuring instruments. It is hoped that this material will be tested for plasticity in liquid hydrogen, and if found to be plastic at that temperature it should be tested in liquid helium.

In closing, the author wishes to urge upon physicists the potentiality of the study of plastic deformation in metals as a means of unlocking some doorways to nature's secrets of the internal structure and properties of solids.

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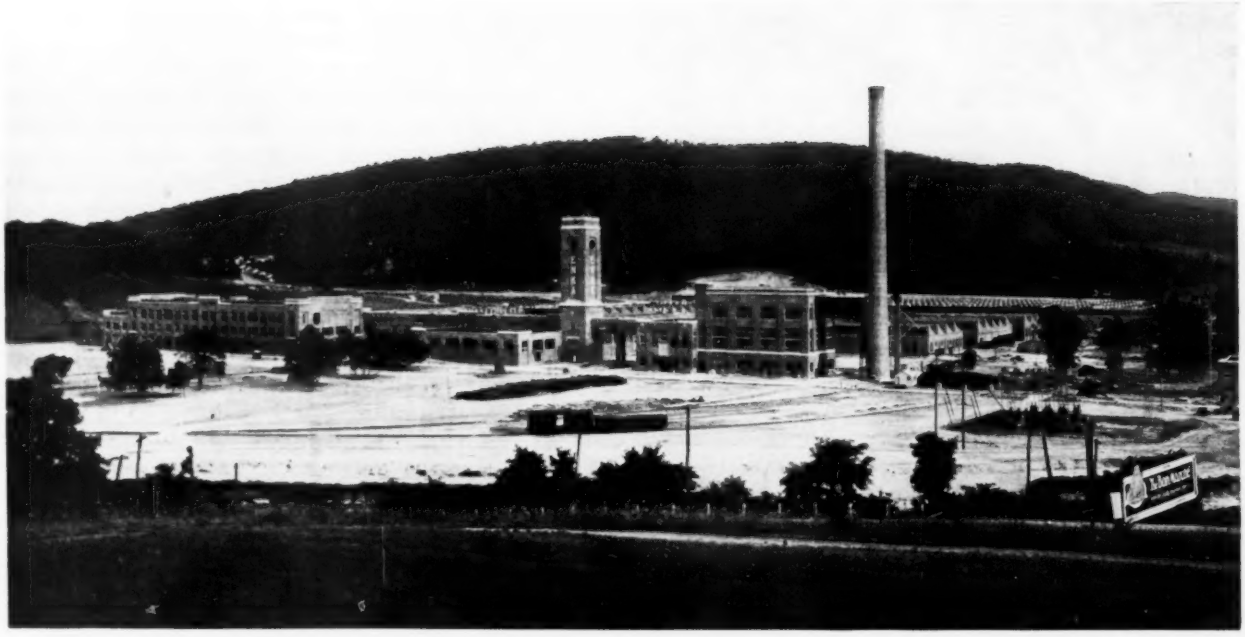
## Centenary of Henry Maudslay

AMONG the pioneers in the improvement of both hand and machine tools none has a more lasting reputation than Henry Maudslay, who died at Lambeth, on February 15, 1831, a century ago. Born at a time when the construction of steam engines and machinery was in its infancy, he lived to see an immense advance in engineering construction, and himself set a new standard in accuracy, refinement, and finish. His shops, moreover, became the recognized training ground for the new generation of mechanical engineers, and his methods found their way into every machine shop in the kingdom.

Perhaps Maudslay's greatest contribution to engineering was his application of the sliding principle to the lathe for the purpose of cutting screws. His machine for originating screws and his two screw-cutting lathes, made about 1800, are among the most interesting of the historic relics preserved in the machine-tool collection in the Science Museum, and no one can look at them without admiring the skill and ingenuity with which Maudslay solved an age-long problem. Whether the idea of a leading screw with change wheels was entirely Maudslay's, it is, today, difficult to say, for Maudslay for several years had the advantage of serving under Bramah, and it was probably in Bramah's shops the slide rest was developed.

Born at Woolwich in 1771, Maudslay began work in the Arsenal at the early age of twelve. When but eighteen, Maudslay was sent for by Bramah, who was at a loss to find a man skilful enough to construct his newly devised locks, and it thus fell out that from gun carriages and the like Maudslay's attention was turned in another direction. For eight or nine years he served Bramah, and then setting up for himself he quickly gained a reputation as a skilful mechanician.

The business growing rapidly, Maudslay, in 1810, purchased the old Riding School in Westminster Bridge Road, and as Henry Maudslay and Company and Maudslay, Sons, and Field, the firm became known all the world over as constructors of marine engines. Roberts, Clements, Nasmyth, and Whitworth were but a few who found their way to Lambeth, and Whitworth's system of screw threads was but a development of Maudslay's own system.—*Engineering*, Feb. 20, 1931, p. 268.



THE RAYON INDUSTRY BUILDS IN LARGE UNITS. THIS IS ONE OF A DOZEN SUCH PLANTS IN THE SOUTH

# Engineering Opportunity in the South

## Industrial Growth of Region in Recent Years Has Called for Much Engineering Skill in Developing Natural Resources

BY EUGENE W. O'BRIEN,[1] ATLANTA, GEORGIA

THERE is much said these days about the marked industrial progress of the South—about steel production centers richly endowed by nature with basic materials, about new-found fields of rich oil, about progressions southward of the textile and other industries. That great section from Virginia to Texas and from Kentucky to the Gulf—almost one-third of our national area—has often been pictured in the throes of an industrial renaissance.

Wonder has been frequently expressed at this sudden descent of industry upon the cotton fields of the South. Yet, fundamentally, the movement is natural enough—despite postponement to this late date. Old and tremendous natural resources plus new capital, and ample native man power plus engineering design and application, form the fundamental elements of industrial progress. They are at this time all available to the South.

### INDUSTRIAL AND ECONOMIC BACKGROUND

To gain a proper perspective of this recent progress, and to measure its degree and characteristics, it is necessary to trace briefly the economic development of the South and study some of the conditions which shunted industry from such a natural field in years gone by.

Early in the nineteenth century the South was industrial. In comparison with the North it produced more than its share of manufactured commodities. It possessed a considerable number of manufacturing plants, foundries, and metal-working establishments, and it might have taken a definite lead in industrial growth had it not been for a mechanical invention—truly an interesting anomaly. For it was the development of the cotton gin, by that ingenious Connecticut Yankee, Eli Whitney, that turned the eyes of the South from its industrial pursuits and fixed them upon the production of cotton. Thus one of the early accomplishments of mechanical engineering made the South "cotton minded" instead of "industrially minded."

Economically, this change was profitable—tre-

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mendously so. The whole world demanded cotton, and only the South could at that time produce it satisfactorily. The rest of the world could manufacture it, but the rest of the world could not raise it. The cotton gin, by replacing an untold amount of unsatisfactory hand labor, removed the last great obstacle to quantity production of cotton at a reasonable price.

This devotion to cotton growing established the plantation system in the South, developed plantation owners and overseers into splendid leaders, and located more than 40 per cent of the wealth of this country in the South by 1860. But this material wealth was almost entirely wasted in the struggle between the states and during the distressing years of readjustment that followed, while the human wealth was very sadly depleted.

Unfortunately, during these trying times King Cotton still held his high position in the South. Heritage, experience, education fostered a belief that cotton would restore the South to its 1860 position. It took years of repeated counsel by such men as William Gregg and Henry Grady to wean the South from this belief and turn its interests to industries based on its own natural resources.

Great as were these resources, their development required capital—capital for investigation of the possibilities, capital for initiation of processes, capital for the building of plants, capital for the education of an organization to carry on production—and capital was lacking.

Eventually, however, Northern capital was made available in gradually increasing amounts to the development of Southern industry, and those individual Southern ventures which had through great persistence and determination established themselves began to earn the capital needed for further extension.

Man power was readily available. The crumbling of the plantation system released leaders of unquestioned ability who found places in industry as opportunity afforded. The great mass of negro labor readily found a place in the new industrial régime, where it could be profitably and satisfactorily employed under the direction of the now industrially minded leaders. As a result, the South is today blessed with a versatility of native labor comparable with its versatility of industry, but requiring instruction and direction which, for lack of time, has not been able, as yet, to accomplish maximum effectiveness.

## Dearth of Engineering Methods

At the beginning of the industrial renaissance, there was a serious dearth of engineering ability and thought in the South. Education had not been directed along engineering lines, experience in engineering matters was lacking. Here and there an engineering perspective was in evidence, but it was the exception rather than the rule. The technical schools which are now graduating men in highly satisfactory numbers had not begun this service to the South.

Industry developed much as did Topsy. Men who had had practical experience in industrial plants, no matter how meager, became counsel to the growth of industry. Owners and managers depended upon them to guide the design and operation of their plants. Many such practical engineers rendered valiant service to the new industry. But, unfortunately, theirs was a method which featured assumptions, estimates, and rule of thumb.

Such substitutes for real engineering were accepted as sufficient, and thrived accordingly, during the initial stages of development, when production costs of the new plants made possible large profit margins in competition with plants in other sections, and before economic study had plumbed the probable depths of development. As a result, early plants in various industries exhibit common incongruities of design and operation which can be traced to the vagaries of opinion of certain individuals whose practical experience gave them positions of authority in the industry.

This stage of development is passing rapidly, although it is still definite enough to be noticeable in certain industries. Real engineering is coming into its own, and is accorded more and more opportunity to serve industrial growth. The gradual narrowing of the margin of profit, the growth of competition between Southern plants themselves, and a greater realization of the ultimate possibilities of Southern industry have resulted in this trend toward engineering.

The indirect influence of the engineer in the recent rise of industry can only be conjectured, although of paramount importance. This indirect influence comes through the development of equipment and of processes which have been adopted by Southern industry, often after trial in other sections. Once new ideas have earned acceptance, the South has been outstanding in its willingness to discard the old and adopt the new. On the other hand, part of the development has been automatic, resulting inevitably from the availability of new machinery as market standards.

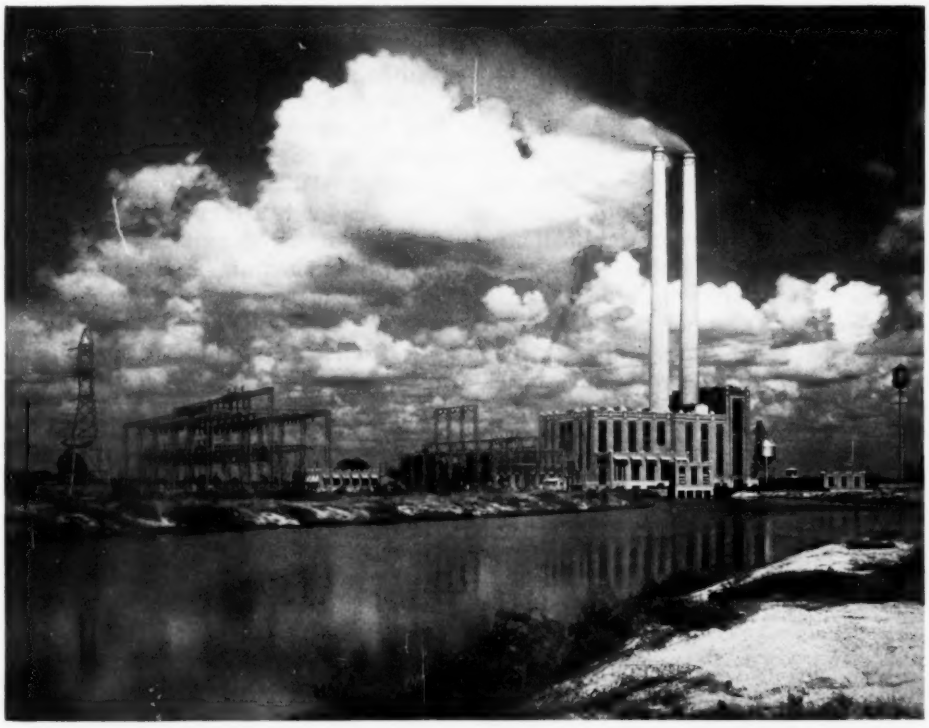
## Industrial Progress Made in Recent Years

By virtue of this joint stimulus of natural resources, new capital, splendid man power, and effective engineering, manufacturing has become in the last twenty years a much more important part of the annual production of the South, amounting now to approximately 60 per cent of the total. This accomplishment has been effected despite its tremendous agricultural and mineral resources.

It is interesting to note the progress made by individual industries in recent years. Perhaps most marked of these industries is the textile, primarily because its trend represents a gain in one section through a loss in another, rather than a marked advance of the industry. About 1910, New England had 50 per cent more active spindles than the South. Today this relation has been reversed. The South now produces about two-thirds of the cloth, and uses about three-fourths of the cotton produced in this country.

Many Northern companies have moved to the South, selling or abandoning their Northern plants, many others have built branch factories in the South, while the original Southern plants have continued to thrive and to plant offspring here and there through the Southeast and Texas.

A number of competent engineering organizations and many individual engineers have served the textile industry in the South in specific plants for years, rendering valiant service, though much of the industry has not been so favored. Fortunately, the influx of Northern plants carried with it a certain amount of technological training that has proved of real assistance, making available the experience and accomplishment of the great Northern textile laboratories.



MUCH OF THE INDUSTRIAL ADVANCE OF THE SOUTH IS PREMISED UPON AVAILABLE POWER. THIS IS ONE OF THE MODERN POWER STATIONS THAT ASSURE RELIABLE AND CHEAP POWER TO INDUSTRY

Perhaps the greatest development in the Southern cotton textile industry within recent years has been the growth of finishing plants. In the early days it was claimed, and later it was complacently assumed, that the muddy streams of the South were unsatisfactory as a source of water for bleaching, dyeing, and finishing. Engineers eventually disproved this claim and assumption, and demonstrated that most of the water could readily be filtered to a clear state, leaving a quite satisfactory water for such purposes.

Associated with the textile industry is rayon manufacture, to which climate, labor, fuel, and a ready supply of cellulose raw materials offer unusual advantages in the South. It is quite natural that the great bulk of rayon progress should be in the Southeast. The approach to this industry is markedly an engineerng one, with operating success measured largely by engineering design.

The steel industry was one of the pioneers, locating largely in Alabama, Tennessee, and West Virginia. The Alabama field has the signal advantage of concentration of ore, fuel, and fluxing materials, claimed to be the only considerable joint deposits of these essential basic materials for steel manufacture in the world. Products of this field enjoy a commercial advantage on the Atlantic and Gulf Coasts by virtue of favorable water rates, and have built Birmingham into a city of over one-quarter million in about fifty years.

The great cellulose reserve of the South becomes evident again in the paper and pulp industry. In the last fifteen years, the importance of the South in this field has doubled from a national point of view. Papers made from Southern wood are gradually replacing those made in the Northern fields, with an increased trend in this direction determined by climatic conditions. The same type of pulp, in certain cases, will grow four times as rapidly in the South as in the North. Recent experiments have indicated the feasibility of producing newsprint from the great growths of scrub pine which heretofore have been considered a nuisance in the South.

The great clay deposits of the South assure widespread ceramic development beyond even that of the last few years. There will undoubtedly be a movement toward increased manufacture of ceramic products at the great Southern bases of supply, particularly as the pendulum of cost and fuel swings further in favor of the South. The principal need of this industry seems to be engineering direction, aimed at refinement of process and control of products.

The petroleum industry in the South is still an infant, but a most lusty one. Its rapid growth has resulted in a certain amount of prodigality, which is bound to be wiped out by competition and the pressing need of conservation of this valuable national resource.

Perhaps no greater proportionate advance has been made in any industry than that of the chemical. Availability of raw material, of fuel and power, and

the development of new processes have brought the heavy-chemical industry of the South into new prominence. Here again the combination of chemical, mechanical, and electrical engineering is the means of progress.

In the old Southern industries such as the cottonseed-oil industry, there is still too much adherence to rule-of-thumb methods. The cottonseed crop is the fourth in importance of the seed crops of this country, being exceeded in value only by corn, wheat, and oats. Its processed value is approximately $250,000,000 a year, with the industry almost exclusively Southern. Yet the oil-mill industry is hardly doing more than breaking even, if that. Lack of economic and engineering study of the industry has resulted in overcapacity, particularly in presses, and in certain poor process practices. Engineering study is particularly needed in such problems as the unloading and handling of the seed, cooling and storage of seed, economical limits of delinting, cooking of the meal, pressing and substitutes, and development of quality and new variety in products.

To make possible the great industrial development sketched above, power had to be available a step ahead of industry. Here again the resources of the South are great, with hills, valleys, and watersheds offering excellent hydraulic possibilities, and with fuel represented by one-third of the country's bituminous coal supply, by great fields of oil and natural gas, and by extensive deposits of lignite, readily available. In the past twenty years the rate of power development in the South has been twice as great as that in the rest of the country.

In public-utility systems, water power has been the spectacular feature, but it has been dependent for economic effectiveness upon fuel-power support. Interconnected with the hydro stations in the electric network which covers the entire South are many steam and Diesel plants serving as base-load, stand-by, and peak-load stations. Fuel power is already the most important factor, and is bound to be increasingly so as steam-station costs decrease while hydro-station costs increase, and as steam-station efficiencies increase while hydro-station efficiencies remain static.

In a great many industries of the South there is need of steam and heat in process—in paper mills, in rayon plants, in bleacheries, etc.; in such plants, greater and greater advantage is being taken of the possibilities of higher efficiency through making the power plant serve both power and steam demand. To take best advantage of such a combined load requires a high degree of engineering skill and knowledge, which is being furnished by the mechanical engineer in the South. As a result of the growing interest in the engineering of power projects, the number of plants buying power that should make it, and the number of those making it that should buy it, are bound to become smaller and smaller.

A most interesting recent development of such engineering application has been the building of central stations adjacent to industrial plants having a large combined power and steam load. The Mobile steam plant of the Alabama Power Company, and the Louisiana Steam Products Corporation plant at Baton Rouge, Louisiana, both furnish steam and power to adjacent industrial developments, and power to a public-utility system.

In summation, the South is a pioneer section in industry, with the engineer and the manufacturer joint pioneers in its conquest. Despite its great natural resources, and its advantages of climate and labor, the twentieth century found the South over fifty years late industrially. Engineering has accomplished a great deal in directing its renaissance, and in providing somewhat better than the minimum amount of technical regulation necessary to vigorous development. In addition to providing routine service in the design and operation of industrial projects in well-defined industries, engineering has provided new processes and new products to take advantage of Southern resources. It has produced building boards and insulation from waste cane fiber and from wood chips, it has pumped hot water through the ground and retrieved it laden with sulphur, it has produced silk from cotton linters and pulp, and edible flour from the cottonseed.

## LOOKING TOWARD THE FUTURE

Looking toward the future, we can expect much progress in the development of new processes and products. The opportunity for the engineer is bound to be greater in the future than in the past, for the crystallizing appreciation of his position in the minds of manufacturers and bankers will give to him the privilege of pioneering industry. Increasing investment costs and decreasing margins of profit will demand more economic engineering study of industry in the future.

But the engineer will fall short if he confines his interests and abilities to strict technology. It will be his privilege and duty to enter more and more into civic activity, guiding the community in affairs having an engineering angle. Particularly will he have an opportunity to direct industry to locations of social and economic advantage to all concerned. He must cultivate the characteristic of looking beyond—of humanizing his work, and of fashioning his professional activities so that they will be of maximum social as well as economic service.

There is one ever-growing resource of the South that has been merely indicated so far, yet perhaps it is as important as any. This is the university-trained technical graduate. Although tremendously handicapped by lack of funds for teaching staffs, laboratories, and other facilities, the Southern universities are turning out each succeeding year more, and better-trained, engineering graduates. They will form the great part of leadership in the future progress of Southern industry, which must offer them the best possible opportunity of development.

# Trends in Steam-Turbine Development

## Higher Temperatures and Pressures—Increased Capacities—Improved Materials—Improved Efficiencies Over Wide Load Range—Adjustment of Turbine to Specific Service—Binary-Fluid Turbines

By A. G. CHRISTIE,[1] BALTIMORE, MD.

THE present trends of steam-turbine development are toward (*a*) the use of higher steam temperatures and pressures, (*b*) increased capacities at the various speeds and increased output from a single casing, (*c*) the employment of better materials for turbine parts and particularly for blading, (*d*) higher efficiency over a wide range of load, (*e*) adjustment of the turbine more closely to the particular requirements of service, and (*f*) the development of binary fluids for use in turbines. The effect of such tendencies will be the production of larger, more reliable, and more economical turbines than those now available.

### Higher Temperatures and Pressures

The possibilities of steam pressures have been determined from the operation of various commercial units to the critical pressure of 3200 lb. per sq. in., and the gains from increases of pressure are now fairly well known. Attention has recently been directed to studies of the effect of higher steam temperatures, which conditions present more difficult problems than pressure alone. Metals such as were formerly used in turbine construction develop undesirable properties at temperatures above 750 deg. fahr. Tensile strength and fatigue limits decrease rapidly at higher temperatures, while the tendency toward that indefinite elongation known as "creep" also increases. The limiting temperature in a steam turbine is therefore fixed by the properties of available metals.

Progress has been made by searching out those materials that may be used safely at the higher temperatures and by designing spindles, blades, casings, etc., to be sufficiently strong under such conditions. "Creep" cannot be entirely overcome. However, parts may be designed so that the working stresses will lead to a rate of creep at the given high temperature which has been considered within safe limits over a period of years. Certain designers have chosen this rate of creep as 0.01 per cent per year, and this or a similar figure may be accepted as a standard rate for high temperatures.

With this rate of creep and with materials now available, turbines can be built for steam temperatures up to 900 deg. fahr. with assurance of satisfactory operation, while units for 1000 deg. fahr. can be constructed with every hope of successful operation throughout their useful life.

Methods of supporting casings for high temperature, and provisions for adequate expansion to eliminate causes of deformation in cylinders, are under development.

The application of higher steam temperatures will have a profound influence on future station design. Previously turbines with no reheating were limited to initial steam conditions of 450 lb. per sq. in. and 750 deg. fahr. If higher pressures were used with the same temperature, the moisture content at exhaust became excessive. Conservative designers aim to keep this moisture content below 12 per cent to prevent erosion in the last blade rows. A single-cylinder turbine of 68,000 kw. with no reheating has already been built for 650 lb. per sq. in., 825 deg. fahr. With 900 deg. fahr. steam temperature, the steam pressure may be raised to 750 lb. per sq. in. Hence substantial increases in steam pressure may be expected in future non-reheating turbines when temperatures above 750 deg. fahr. are employed.

A large number of American stations now use, or will soon use, 1200 to 1400 lb. per sq. in. steam pressures with steam temperatures of 750 deg. fahr. and with a single stage of reheating. Steam temperatures of 900 deg. fahr. may make it economical to increase the steam pressure of reheating stations to 2000 or 2500 lb. per sq. in.

Steam conditions in future stations will probably be standardized as follows: with no reheat, 400 lb. per sq. in., 750 deg. fahr., and 700 lb. per sq. in., 850 deg. fahr.; and with one stage of reheat, 1400 lb. per sq. in., 750 deg. fahr., and 2000 to 2500 lb. per sq. in., 900 deg. fahr. In the latter case two stages of reheat may be used if high efficiency is desired.

These considerations apply in general to large central stations. However, the gains from increased tem-

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peratures and pressures are equally applicable to industrial plants. When such plants operate without vacuum or exhaust against back pressure into a service main, the proportional gains from using high pressure

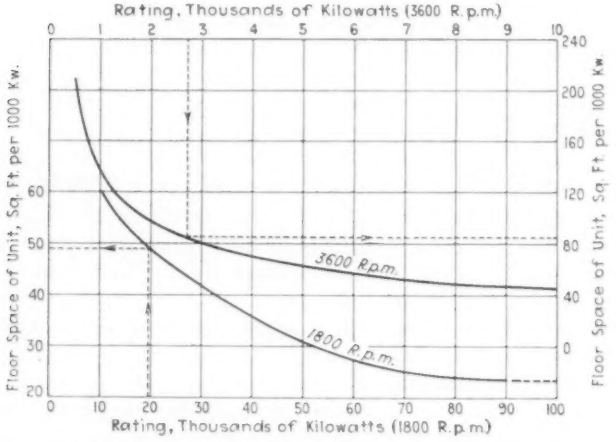
Rating, Thousands of Kilowatts (3600 R.p.m.)
Floor Space of Unit, Sq. Ft. per 1000 Kw.
3600 R.p.m.
1800 R.p.m.
Rating, Thousands of Kilowatts (1800 R.p.m.)

FIG. 1 FLOOR SPACE REQUIRED FOR SINGLE-CYLINDER 3600-R.P.M. TURBINE ALTERNATORS AND ALSO FOR SINGLE-CYLINDER 1800-R.P.M. UNITS

(This area consists of a rectangle enclosing turbine, generator, and direct-connected exciter, with an added rectangle for any offset valve gear.)

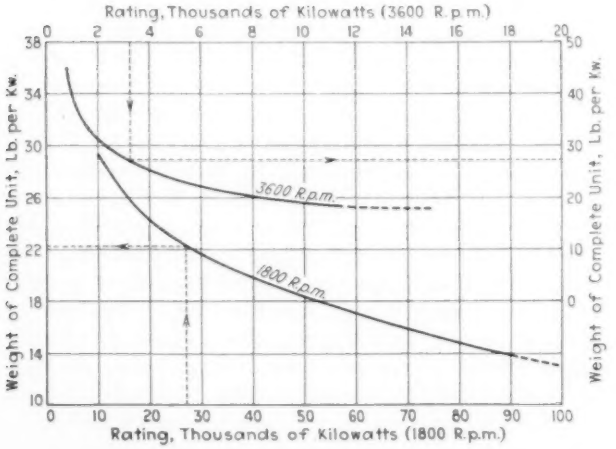
Rating, Thousands of Kilowatts (3600 R.p.m.)
Weight of Complete Unit, Lb. per Kw.
3600 R.p.m.
1800 R.p.m.
Rating, Thousands of Kilowatts (1800 R.p.m.)

FIG. 2 WEIGHTS OF SINGLE-CYLINDER 3600-R.P.M. TURBINE GENERATORS AND OF 1800-R.P.M. UNITS

and high superheat are larger than in condensing central stations.

## INCREASED CAPACITIES

The use of turbines of large rated capacities results in several economic gains. Floor space per kilowatt decreases with increasing size as shown in Fig. 1. This results in a smaller turbine room and a lower building cost per kilowatt. Steeple compounding has been introduced to provide a further saving in floor space. Manufacturers are endeavoring to reduce the lengths of their turbo-generator sets to save more floor space. The weight per kilowatt decreases with increased ratings as indicated by Fig. 2. Hence foundation costs are lessened. Attention is drawn to the decreased weight of units that operate at 3600 r.p.m. as compared with units of the same rating at 1800 r.p.m. Fig. 3 shows that the efficiency also tends to increase with higher turbine capacities, though at a lesser rate in the largest units. First cost per kilowatt (see Fig. 4) also decreases with increased capacity. The economic justification for the trend toward higher capacities is evident from a consideration of these data.

Single-cylinder condensing units of 10,000 kw. at 3600 r.p.m. have been built in this country. C. A. Parsons & Co. have single-cylinder condensing units

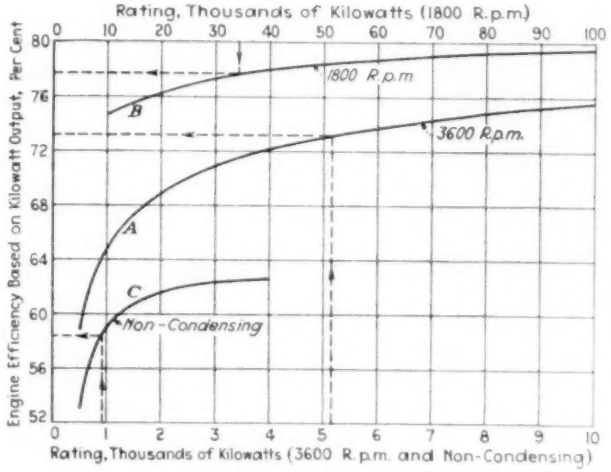
Rating, Thousands of Kilowatts (1800 R.p.m.)
Engine Efficiency Based on Kilowatt Output, Per Cent
1800 R.p.m.
3600 R.p.m.
Non-Condensing
Rating, Thousands of Kilowatts (3600 R.p.m. and Non-Condensing)

FIG. 3 AVERAGE ENGINE EFFICIENCY FOR THE LOAD POINT OF BEST EFFICIENCY BASED ON KILOWATT OUTPUT AT THE GENERATOR TERMINALS

Curve A: Single-cylinder turbines at 3600 r.p.m., for steam conditions up to 300 lb. per sq. in. gage, 600 deg. fahr., 28.5 in. vacuum.
Curve B: 1800-r.p.m. turbines for steam conditions up to 450 lb. per sq. in. gage, 750 deg. fahr., 29 in. vacuum.
Curve C: Non-condensing units for steam conditions up to 250 lb. per sq. in. gage, 550 deg. fahr., atmospheric pressure at exhaust.

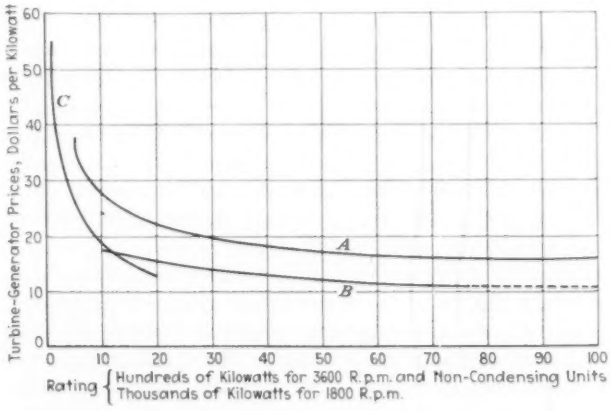
Turbine-Generator Prices, Dollars per Kilowatt
Rating { Hundreds of Kilowatts for 3600 R.p.m. and Non-Condensing Units
Thousands of Kilowatts for 1800 R.p.m.

FIG. 4 PRICES FOR TURBINE-GENERATOR UNITS IN THE UNITED STATES

Curve A: 3600-r.p.m. condensing units.
Curve B: 1800-r.p.m. condensing units.
Curve C: Small non-condensing sets.
(Prices include bare turbine and generator without auxiliary generators or direct-connected exciters and are for units delivered and erected. Prices are for pressures up to 400 lb. per sq. in. gage, steam temperatures up to 725 deg. fahr., and, when condensing, up to 29 in. vacuum.)

of 15,000 kw. at 3600 r.p.m. in operation, one at Regina, Saskatchewan, Canada, and are offering similar turbines of 20,000 and 25,000 kw. with one casing. The largest unit at 1800 r.p.m. with a single cylinder

has a capacity of 80,000 kw. These single-cylinder units of high capacity pass such great volumes of steam through the last row of blades that the leaving losses are large. Such losses tend to offset the gains in engine efficiency which come with increased size. As the result, these large units cannot be expected to establish records of efficiency. However, American engineers favor the single-cylinder units as they decrease station cost and are simpler to operate.

Attention has already been drawn to the large sizes of single-cylinder turbines now available at 3600 r.p.m. Turbines can be built at this speed up to 50,000 kw. in two tandem cylinders, and up to 100,000 kw. when two low-pressure cylinders in tandem are provided. These turbine capacities are beyond the limits of any 3600-r.p.m. generators developed to date. These compound units have certain economic advantages that deserve consideration. Their weight is less than that of a unit of similar capacity at 1800 r.p.m. The shafts are shorter between bearings, and, having less mass, can start under high-temperature conditions more rapidly than units of the same size at 1800 r.p.m. Finally the efficiencies with the same blade speeds and same kilowatt rating are higher in the 3600-r.p.m. than in the 1800-r.p.m. units. These advantages, when more generally recognized, will lead to a wider use of large turbines at 3600 r.p.m.

Multi-cylinder units at 1800 r.p.m. have been built in tandem up to 160,000 kw. Such tandem compound units for large capacities are finding favor among power-plant designers and will be used more extensively in the future. Triple-tandem turbines up to 150,000 kw. at 1800 r.p.m. for 1200 lb. per sq. in. are under construction. Cross-compound turbines with several generators ranging up to 208,000 kw. are being used in increasing numbers. The trend in central-station practice is toward the use of larger units, and the capacities mentioned will be exceeded when system loads warrant the increased sizes of turbines.

## Improved Materials

The manufacture of shafts and turbine disks has been improved through better steel-foundry and forge-shop practices, through internal inspection by means of bore holes, through vibrating the disks before assembly, and through careful static and dynamic balancing after completion. As a result of improvements in these practices, troubles with such elements are steadily diminishing.

Many turbine difficulties are traceable to blade troubles. Blade vibration is a common cause of failure. Much research work must still be done to find the proper location of lashing wires, the correct method of silver-soldering these wires, the best form of shrouds, and even the most effective form, size, and angles of the blades themselves to resist vibration in the larger sizes of turbines now used.

Two trends in turbine development have been responsible for much blade trouble. In order to secure added capacity and improved efficiency, blade speeds have been steadily increased until tip speeds of 1150 ft. per sec. are now in use. These operating conditions require long blades of high strength and rigidity. Such blades are liable to vibrate. The second trend is the increasing use of large heat drops at high efficiency, which lead to high moisture contents in the exhaust steam. This moisture causes rapid erosion of the blades in the last rows of the turbine, which not only decreases turbine efficiency but also increases the risk of failure of low-pressure blading and, further, necessitates the replacement of such blades every three to five years. Such replacement is expensive and necessitates a serious outage. Future developments will provide alloy steels for use at these high blade speeds which will have longer life under the wet-steam conditions in the last rows.

Stainless steels at present seem best suited for long blades. A steel with about 12 per cent chromium and 0.1 per cent carbon has given much promise for such service.

Moisture is difficult to remove from this low-pressure steam. Different schemes such as drainage grooves, bypass orifices, etc. have been tried, but the best results so far reported only indicate the removal of about 25 per cent of the total moisture. A study of eroded blades shows that the destructive moisture is concentrated on the outer half of the blade but not wholly at the periphery. The droplets are undoubtedly of small size and difficult to separate from steam at high velocity. Hence the ineffectiveness of the various catchers and other devices.

The late Professor Goodenough offered the theory that the water droplets travel through the stationary nozzles and blades at a slower speed than the steam, and thus do not enter the blades at the proper relative angle. The faster-traveling steam enters the blades tangentially, as it should, but the slower water droplets are struck by the back of the blade and rapid erosion results. This explains why erosion occurs on the back of the inlet edge of the blade.

Of the various blade materials tried under these conditions, properly heat-treated stainless steels and some nickel alloys seem best. Plating the edges of these blades with erosion-resisting metals has been tried, and heavy plating of chromium appears promising. Sprayed coatings of tantalum, sheaths of Hecla and other metals, coatings of stellite, and nitriding also appear to resist erosion and are being further investigated. There is reason to expect that an erosion-resisting blading may soon be developed.

A suggestion has been made to provide hollow stationary blades or hollow diaphragm partitions in which a hot medium can circulate. The heat from these blades would dry the low-pressure steam passing them. If this can be done, it would not only decrease erosion but would increase turbine efficiency. Turbine builders and users now recognize the seriousness of the problem of properly dealing with this wet exhaust steam. Further research will develop improvements in materials or ways of eliminating the trouble.

Oxidation difficulties in blading have been largely overcome through careful deaeration of feedwater. Some dissociation may later be found in high-temperature superheaters, but its effects are at present hard to predict.

Much trouble has resulted from deposits on turbine blading, and a technique has been developed to remove this in stations where the deposits are troublesome. Purer make-up for boiler feedwater, less condenser leakage, and drier steam from boiler drums to superheaters will do much to overcome this trouble.

## IMPROVED EFFICIENCIES OVER WIDE LOAD RANGE

Efficiency in turbines is largely a matter of price.

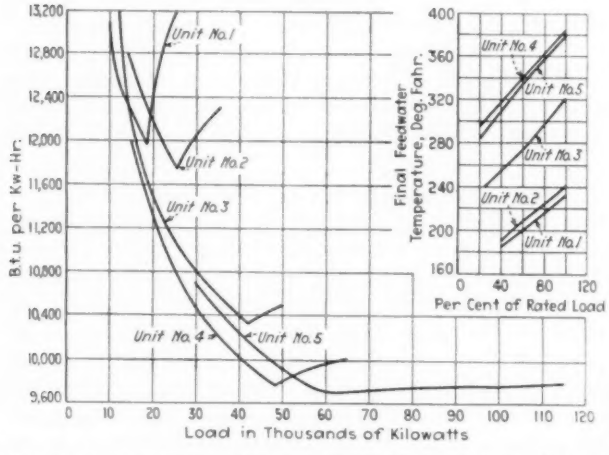


FIG. 5 IMPROVEMENT IN STEAM-TURBINE PERFORMANCE. ECONOMY CHARACTERISTICS OF A SERIES OF FIVE UNITS INSTALLED AND BUILDING FOR A CENTRAL STATION DURING A PERIOD OF EIGHT YEARS

Unit No. 1: 25,000 kw. at 93 per cent power factor. Operating conditions: 350 lb. per sq. in. gage, 675 deg. fahr., 29 in. vacuum, 2-stage bleeding. Installed in 1923.
Unit No. 2: 35,000 kw. at 93 per cent power factor. Operating conditions: 350 lb. per sq. in. gage, 675 deg. fahr., 29 in. vacuum, 2-stage bleeding. Installed in 1925.
Unit No. 3: 50,000 kw. at 85 per cent power factor. Operating conditions: 600 lb. per sq. in. gage, 725 deg. fahr., 29 in. vacuum, 4-stage bleeding. Installed in 1927.
Unit No. 4: 65,000 kw. at 85 per cent power factor. Operating conditions: 600 lb. per sq. in. gage, 725 deg. fahr., 29 in. vacuum, reheat to 725 deg. fahr., 4-stage bleeding. Installed in 1930.
Unit No. 5: 115,000 kw. at 95 per cent power factor. Operating conditions: 625 lb. per sq. in. gage, 750 deg. fahr., 29 in. vacuum, reheat to 750 deg. fahr., 4-stage bleeding. To be installed in 1931.
(From data furnished by Allis-Chalmers Mfg. Co., Milwaukee, Wis. Final feedwater temperatures at various percentages of rated load are also shown.)

Each manufacturer offers units which will give about the same efficiency and will sell at about the same price as those of his competitors. Turbines of higher efficiency than these commercial units can be built if one is prepared to pay the higher cost of these improved designs. Load conditions, early supersession by more modern units, changing steam conditions, low fuel costs, and other factors frequently make it uneconomical to purchase a turbine of the highest efficiency. Nevertheless the performance of steam turbines is being steadily bettered, and this improvement will continue.

Large turbines are generally provided with bleeders, and some have reheaters. Hence performance is best expressed in terms of B.t.u. per kilowatt-hour rather than in pounds of steam per kilowatt-hour.

The gains in efficiency from improvements in the design will be comparatively small for any particular feature, but in the aggregate may lead to substantial advances. Efficiencies of 82 to 85 per cent at the coupling are obtained on some American turbines, while an efficiency of 87.7 per cent at the coupling is claimed for a European turbine of 85,000 kw. As previously stated, the high leaving losses inherent in the design of many turbines of large capacity lead to moderate efficiencies of such units. Better performances may be expected to result from lower leaving losses, from reduction of moisture in exhaust stages, from improved blading in the high-pressure section, and from a greater combination of impulse and reaction effects in all blading. Regarding the latter, there is already a tendency to secure reaction effects from blading on types of turbines which were formerly considered as of the pure impulse type.

Recent designs provide for high efficiency in B.t.u. per kw-hr. over a wide range of load through the use of secondary, tertiary, and even quaternary inlet valves. This is shown in Fig. 5 where the heat consumption of the largest unit does not vary more than 100 B.t.u. per kw-hr. from 55,000-kw. to 115,000-kw. loads. The governor design becomes more complicated when such additional admission valves must be controlled. Manufacturers provide inherent excess capacity in many turbines so that full load can be maintained should boiler pressure drop below normal. But generators are designed with little spare capacity, and if additional overload capacity is desired this must be specified and paid for; or, the generator may be purchased for a lower power factor.

The gains in heat consumption obtained through the use of bleeder heaters have been fully analyzed and discussed and are generally understood by engineers. These bleeder heaters have usually been of the closed type. Successful operation of the high-pressure direct-contact heaters at South Amboy Station may lead to a more extended use of this type.

The last high-pressure heater is frequently furnished with highly superheated steam. It is possible to design a counter-current closed heater to take advantage of this superheat and thus raise the feedwater above the saturation temperature corresponding to the steam pressure in this heater.

Mr. Warren Viessman and the author showed in a recent paper[2] that, after a turbine has been fully loaded with all bleeders in service, still further gains in turbine capacity can be secured by cutting off bleeder heaters at the time of peak load. To demonstrate these possibilities, a turbine receiving 673,000 lb. of steam per hour at 450 lb. per sq. in., 750 deg. fahr., and exhausting at 29 in. vacuum was assumed to have four bleeder heaters. If all these are shut off at the time of peak load, the station capacity can be increased

[2] "Low-Cost Peak-Load Capacity With Bleeder Turbines," by Warren Viessman and A. G. Christie. Presented at a meeting of the Metropolitan Section of the A.S.M.E., January 8, 1931. Published in MECHANICAL ENGINEERING, February, 1931, p. 111.

17.7 per cent, but the cold condensate to the boiler would increase boiler output about 27 per cent. Hot-water storage after the last bleeder heater would permit peak-load operation with bleeders out of service for two hours, and with no change in boiler capacity, and would give the 17.7 per cent increase in capacity. This plant can be installed together with added generator capacity for about $24.35 per kw. The adjusted station heat consumption per kilowatt-hour is practically the same for the peak load with the bleeders cut off as during normal operation. A cheaper arrangement giving the same increase in capacity is one where the hot-water storage is placed at low pressure after the second bleeder heater. In this case boiler capacity must be increased 15.4 per cent. The increases in station capacity with large numbers of heaters are 10 per cent for three heaters, 17.7 per cent for four, and 21.25 per cent for five. The paper discusses other methods of increasing peak-load capacity by discontinuing the use of bleeder heaters when there is no objection to colder feedwater and to additional forcing of boilers. These gains in capacity by cutting off bleeder heaters can be secured after all the gains from other means of overloading have already been obtained. Such methods of providing additional capacity at peak loads can be employed in many present and future central stations.

Reheating of steam is necessary with pressures of 1200 lb. per sq. in. and above. Flue-gas reheating is apparently gaining ground on account of the marked improvement in station economy achieved by its use. Steam reheating is more convenient in certain stations, but is less economical than gas reheating. The use of diphenyl oxide for reheating purposes is being investigated, and appears to have interesting possibilities.

The use of hydrogen for generator cooling will probably be the next improvement in turbo-generator construction. All experimental units appear to be satisfactory. Fans for circulating the cooling medium—whether air or hydrogen—should be separate from the generator and be designed for variable speed on large units to save auxiliary power at light loads.

### Adjustment of Turbine to Specific Service

The desire to reduce power costs by keeping station investment at a minimum, led to a study of turbine frames and their economic ratings as fixed by their probable use factor throughout their whole operating life, and by the cost of fuel. It is obvious that with low use factors and cheap coal, leaving losses can be increased and the output of a given casing can be greater, thereby reducing first cost, than in the case of a base-load station with expensive coal. Fig. 6 from a study by Francis Hodgkinson, of Westinghouse Electric & Manufacturing Co., shows that a casing may have an economical rating from a dollar standpoint ranging from 30,000 to 50,000 kw. depending upon the value of $K$, which is the product of the use factor, expressed as a decimal, and cost in dollars per 1000 lb. of steam. If the most economic installation is to be secured for a given service, it is evident that there must be close cooperation between the manufacturer and the engineers of the purchaser in order to find which turbine frame and what rating of this frame will develop power at the lowest total cost in any given plant. No frame hereafter will have one fixed rating.

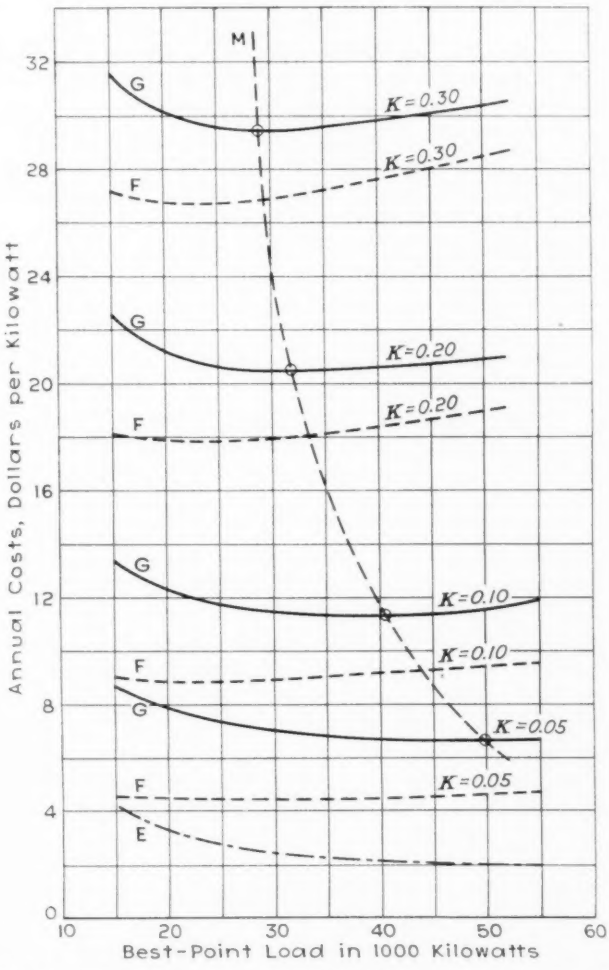


FIG. 6 FIXED CHARGES, ANNUAL OPERATING COSTS, AND TOTAL ANNUAL COSTS FOR TURBINE GENERATOR WITH VARYING USE FACTORS AND STEAM COSTS PLOTTED AGAINST VARIOUS RATINGS. (THIS REACTION TURBINE HAS A LAST-BLADE ANNULUS OF 57 SQ. FT.)

Curve E: Annual fixed charges in dollars per kilowatt, based on 17 per cent of the first cost of turbine-generator installed and including piping and foundations.

Curves F: Annual operating costs for various values of the product of use factor and costs per 1000 lb. of steam.

(Operating costs are based on the average load carried with an average steam consumption 2½ per cent higher than that calculated for the given load from assumed data. Hence annual operating costs = steam consumption in lb. per kw-hr. at given load as calculated from assumed data ÷ 1000 × 1.025 × cost of steam per 1000 lb. × use factor × 8760.)

Curves G: Total anual costs = Curve E + Curve F for each value of $K$.

Curve M: Loci of minimum values of G curves for various values of $K$.

The same degree of cooperation between turbine builder and purchaser is essential in the choice of an industrial turbine, particularly where this is of the reducing or bleeder type from which steam is to be taken for industrial purposes. The problems of such turbines are becoming increasingly complicated and require the best engineering skill for their successful solution.

Special turbines of rugged design, capable of being started quickly, and of high capacity for a given frame, have been used as steam stand-by units for hydro-electric systems.

Future turbines will be better suited to their services than those now in use.

### Binary-Fluid Turbines

The excellent performance of the mercury boiler and turbo-generator plant at Hartford, Conn., has definitely established that combination as a commercial unit. For ten months last year this plant operated at a heat rate of 10,310 B.t.u. per kw-hr. of net station output. Engineers expect to ultimately reduce this consumption to about 8500 B.t.u. per kw-hr. No data are available regarding initial and operating costs. Consideration must be given to this combination in planning a new plant, particularly if this plant is for a base load or for high use factors.

The success of the mercury turbine will encourage attempts to develop processes to use other materials than mercury such as diphenyl, diphenyl oxide, and zinc ammoniate. Some of these, or others yet untried, may prove suitable for power-plant use.

### Probable Limiting Performance

One will ask, "What is the probable limiting performance to be expected of a steam turbine?" This has not yet been approached, and American economic conditions may never warrant the plant investment to achieve this ultimate end. Probably the best estimate of this limiting performance is that for a large plant with steam at 2500 lb. per sq. in. and 1000 deg. fahr., having two stages of reheating to the same temperature, and with six stages of bleeder heating, leading to a station heat rate of about 9500 B.t.u. per kw-hr. of net output. Within the bounds of our present knowledge, this may be taken as the best performance to be expected of a steam turbine.

With particular reference to the efficiency shown for the non-condensing units, the writer believes this curve must have been based on non-condensing turbines which are not of the latest design or perhaps units which are now obsolete.[3] Therefore it is felt that the line for non-condensing units should be brought up to date, because a comparison of the efficiencies of condensing and non-condensing turbines as shown by these curves is likely to lead to an erroneous impression as to the relative efficiencies of these two types.

As a matter of fact a non-condensing turbine of comparable design will average a little better in efficiency than the same rating of condensing unit.

There are obvious reasons for the better efficiency in the non-condensing turbine. Considering normal operating conditions, the non-condensing unit does a much greater percentage of its work in the superheat field as compared to the condensing turbine. Due mainly to the comparatively short heat drop, and the resulting larger quantities of steam used, the physical proportions of the non-condensing turbine for a given rating are favorable. The turbine shaft can be of comparatively large diameter with good blade heights, resulting in a rugged design with good leakage characteristics. Due also to the short heat drop, ideal conditions of velocity ratio are more easily attainable, and because of the small specific volume at exhaust, leaving-loss difficulties are reduced to a minimum.

Fig. 7 shows the normal efficiencies of turbo-generator units for the three types considered, and it is believed

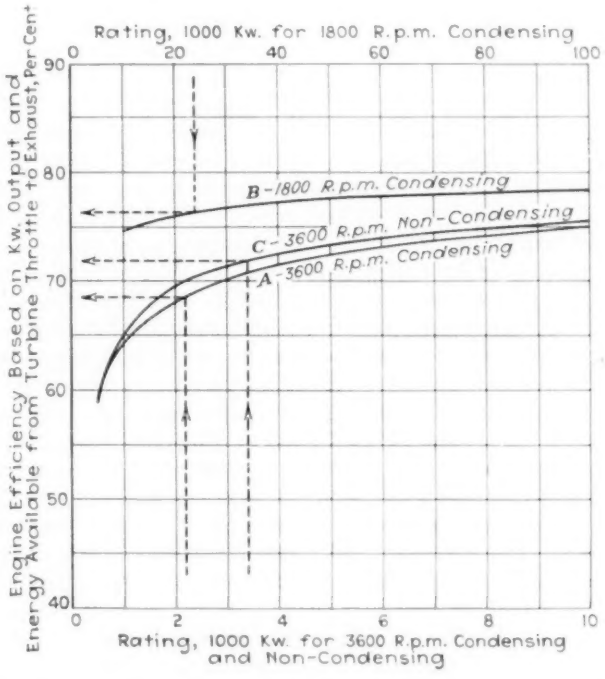


Fig. 7 Normal Efficiencies of Steam Turbo-Generator Units (Operating conditions according to average of present practice for the various ratings and types.)

that this graph represents the present practice, especially when considering the comparative efficiencies of the three types. The efficiency is expressed as the Rankine-cycle efficiency ratio based upon the kilowatt output of the generator and the energy available from the turbine throttle to exhaust, thus including the generator efficiencies and regulation loss. The efficiency represented is for the load of maximum efficiency for a unit of given rating. The curves consider average or normal operating conditions according to present-day practice for the types and ratings considered. The average conditions, of course, will vary considerably, depending upon the type and rating.

In regard to the question of the efficiency of high-pressure non-condensing turbines, the records of single-cylinder high-pressure units and the performances of the high-pressure elements of tandem units are proof enough that very good efficiencies are being obtained with non-condensing-turbine designs over a wide range of operating pressures.

[3] Discussion contributed by R. T. Luce, Steam Turbine Department, Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

# The Manufacture of Lead-Covered Paper-Insulated Telephone Cable

## Particulars Regarding New Developments Comprising the Direct Application of Wood-Pulp Insulation, Improved Cable Stranding, Vacuum Drying, and the Central Melting of Large Quantities of Lead Alloy and Its Distribution Through Piping to a Number of Sheathing Presses

By JOHN R. SHEA,[1] KEARNY, N. J.

PAPER-INSULATED lead-covered telephone cable constitutes approximately 25 per cent of the Bell System telephone plant. The cost of new telephone cable each year, including installation, is approximately $100,000,000. Developments in the process and equipment for its manufacture are numerous, and have been a large contributing factor in the establishment of a high standard of service in the long-distance communication field. The problems involved in manufacturing cable are extremely interesting both from an economic and technical standpoint to the mechanical and the electrical engineer, the physicist, and the chemist, and the illustrations which follow contain fundamental engineering principles of use in many lines of industry.

### Manufacture of Cable

A typical long-distance telephone cable (toll cable) consists of "quads" (double pairs) of paper-insulated electrolytic copper wire (No. 16 to No. 22 B. & S. gage) built up in layer construction and covered with a lead-antimony alloy sheath $2^{5}/_{8}$ in. in diameter and $^{1}/_{8}$ in. thick. See Fig. 1.

The raw materials for such cable consist of high-grade lead in pig form, annealed electrolytic copper wire, and large jumbo rolls of manila-rope wood-pulp paper. The first operation consists of slitting the large rolls of paper into disk-shaped pads. A sufficient number of these pads are placed in an insulating machine which applies the paper to the copper wire in spiral form at a head speed of from 1470 to 2400 r.p.m. (see Fig. 2). The insulated wires are paired very carefully and then placed in a machine which first twists the pairs and then forms them into twisted quads (Fig. 3).

The quads of wire thus built up are placed into a strander. One quad serves as a center about which other quads are laid in alternate layers as the material progresses through the machine (Fig. 4). Step by step it is thus built up, one layer being applied by each drum until the full amount is obtained, after which an outer wrapping of paper is applied to retain the insulated wires in shape and also serve as an additional insulation from the lead sheath.

All telephone cable for local service (loop cable) until recently was made in much the same manner. Recently two new processes have completely revolutionized its manufacture.

### Direct Application of Wood-Pulp Insulation

The process and machine recently developed to apply wood pulp direct on wire combine the steps of paper making, slitting, and insulating into one operation, and give a continuous sleeve of pulp paper around the wire.

Essentially, the process consists in forming simultaneously on a modified cylinder paper machine, 50 narrow continuous sheets of paper, with a single strand of wire enclosed in each sheet, pressing the excess moisture from the sheets, turning them down by means of a rapidly rotating polishing device, so as to form a uniform cylindrical coating of wet pulp around the wire, and then driving the water from this coating by drying.

The material used in making this insulation is Kraft pulp, which is prepared for use on the machine by beating as in the ordinary paper-making operation, Fig. 5, and fed to the machine in a somewhat more diluted form than in standard paper-making practice.

Ordinary annealed copper wire has a non-uniform surface due in part to the residual drawing compound. A satisfactory surface is obtained by passing the wire through an alternating-current electrolytic cleaning bath before it enters the paper-forming machine. A narrow sheet is formed on each conductor in an ordinary single-cylinder paper machine, the mold of which has been divided into 50 parts by means of celluloid strips

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[1] Assistant Engineer of Manufacture, Western Electric Co., Inc. Assoc-Mem. A.S.M.E. Since graduation from the University of Wisconsin in 1909, Mr. Shea has been engaged in various capacities by the Western Electric Co. In 1927 he made an extended investigation of European wire drawing and cable making, and since then has directed the engineering of equipment and processes of the company's Baltimore, Md., cable plant, in addition to being responsible for similar activities for the entire Kearny, N. J., plant.

For presentation at the "Three-M" (Management, Materials, Maintenance) Congress to be held in Cleveland, Ohio, April 13 to 17, 1931, under the auspices of the A.S.M.E. and the S.I.E. Abridged.

and so arranged that a part of the sheet of paper is formed before the wire comes in contact with it. The remainder of the sheet is then laid down on top of the wire without any break in the formation, and the resulting narrow ribbon of paper carries the wire imbedded in it. Thus fifty conductors are insulated simultaneously. Two sets of press rolls take the excess moisture from the sheet, and leave it ready for the polishing operation. Various types of polishers have been developed, and the one now in use consists of two short, specially shaped blocks, with a third block located about centrally to the other two. These polishers are rotated very rapidly around the wire, Fig. 6. Their construction is such that if an occasional lump or break occurs in the sheet it does not cause clogging of the polisher. Polished wet insulation carries about 70 per cent water by weight, which has to be driven off by heat. The drier consists of a 25-ft. long electric box-type furnace with heating elements extending the full length of the top, and additional heating elements in the first 8-ft. section of the bottom. These elements are thermostatically controlled so that the temperature of the furnace can be set so as not to cause charring of the insulation as it passes through the drier, Fig. 7. Two spooling positions are furnished at the take-up for each wire, so that as soon as one spool is full, the wire can be shifted to an empty spool and the full spool removed, Fig. 7. The normal speed of the machine is approximately 110 ft. per min., and the output per week is about 45 million conductor feet.

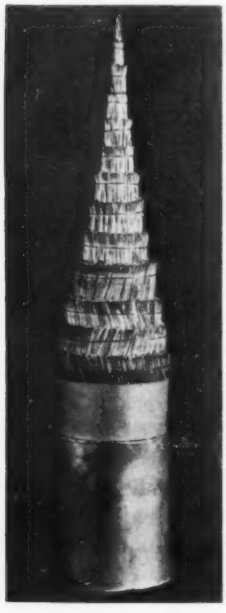

FIG. 1 TYPICAL CONSTRUCTION OF LONG-DISTANCE TELEPHONE CABLE

The electrical properties of telephone loop cable made from this material compare favorably with those made from ribbon insulation, and the annual saving per machine is an appreciable factor due largely to the lower cost of raw material.

### IMPROVED CABLE STRANDING

Until recently all local cable (loop cable) was built up or stranded by the concentric-layer method at a speed of 50 to 100 ft. per min. (see Fig. 4). This construction is being rapidly superseded by a unit method, the first application of which was made on the 1818-pair 26 B. & S. gage cable.

The unit method consists of two distinct steps. A flier strander is used to strand pairs into individual color groups known as units, which usually consist of 50, 51, or 101 pairs. A cabling machine then assembles a definite number of these units into a round core form. Thus the final cable size is some multiple of 50, 51, or

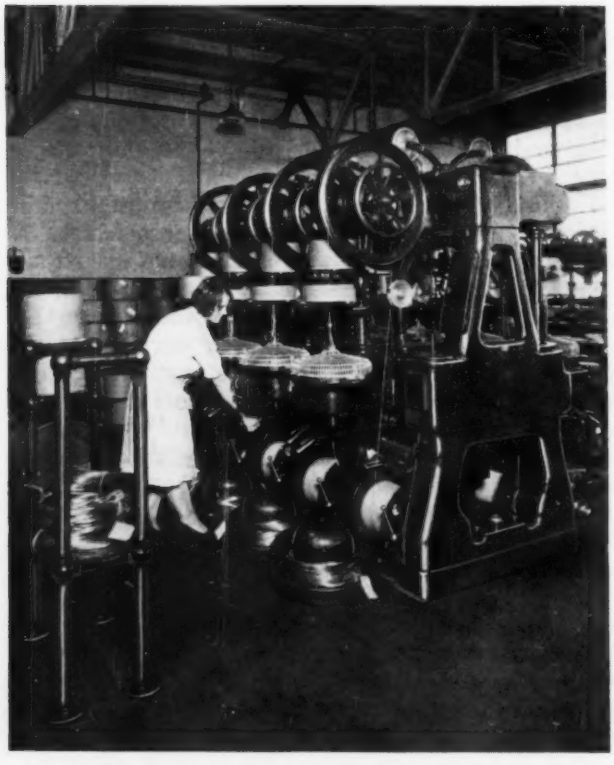

FIG. 2 INSULATING MACHINE WRAPPING PAPER SPIRALLY AROUND COPPER WIRE

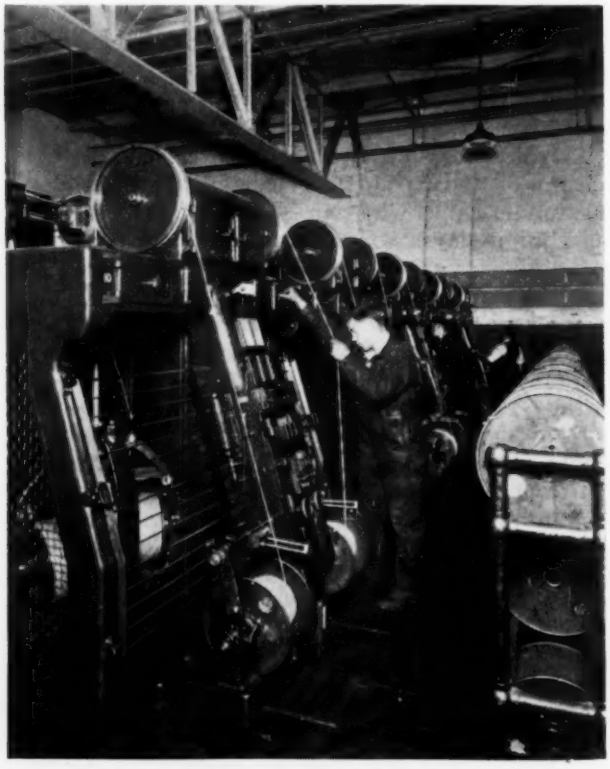

FIG. 3 MACHINE FOR TWISTING PAIRS OF INSULATED WIRES AND THEN FORMING THEM INTO TWISTED QUADS

101 pairs. An 1818-pair cable built in this manner is shown in Fig. 8.

The flier strander shown in Fig. 9 consists of a reel carriage or drum for holding 101 supply reels of paired wire; a cotton serving head for winding a cotton thread about the unit; a flier for stranding the unit; a pulling mechanism or capstan for advancing the unit through the machine; and a take-up for reeling the finished unit on a core truck.

By revolving the flier about the normally stationary supply it is possible to obtain two twists in the unit per flier revolution. This combined with the low inertia of the flier permits units to be stranded at the rate of 300 ft. per min.

The cabling machine shown in Fig. 10 consists of 18 supply stands equipped with suitable pneumatic brakes for holding and maintaining tensions on the trucks of units, and a rotating capstan take-up. The units are pulled through a distributer plate and covered with a protective wrap of paper. A twist is put in the cable between the distributer plate and the entrance point of the cable to the capstan. The finished cable is taken up on reels that contain three times the cable that is possible on the core trucks used with the concentric stranding machine. These reels of cable are then handled through subsequent manufacturing processes by electric trucks.

The outstanding advantages of this new type of construction are that less copper and paper are required in building up large sizes of cable. With the same investment in machinery and building, a much larger production may be obtained. Much finer gages of

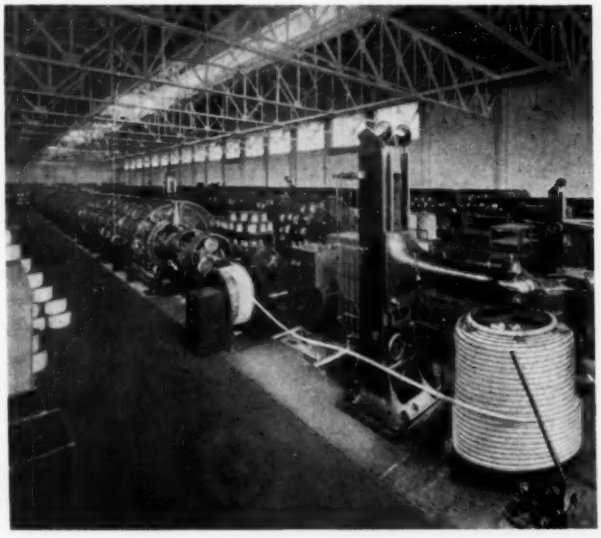

Fig. 4 Stranding Quads Into Cable Form

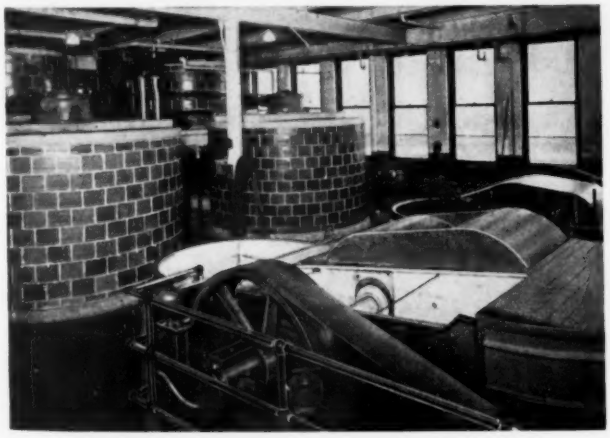

Fig. 5 Equipment for Beating Kraft Pulp and Tanks for Its Storage

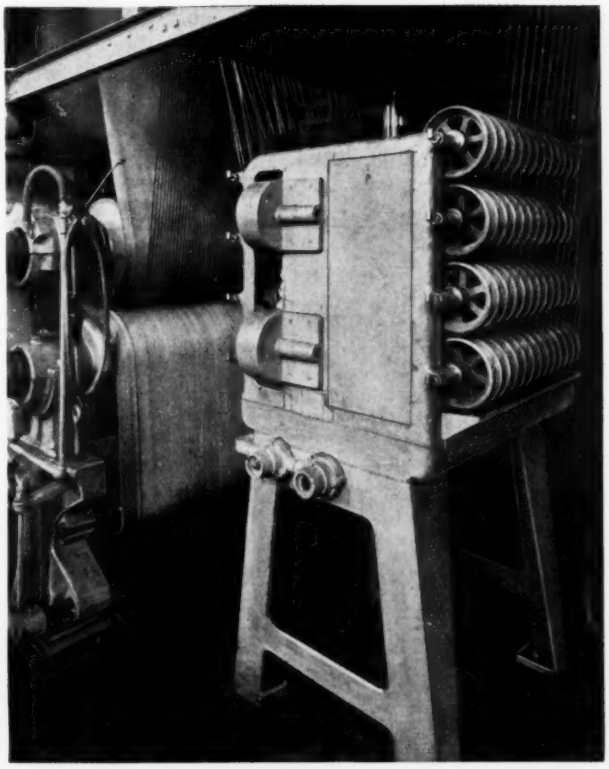

Fig. 6 Machine for Polishing Paper Insulation After Its Application to the Wire

Fig. 7 Equipment for Drying the Moisture Out of Insulated Wire Leaving Polisher

wire may be stranded without danger of stretching beyond its elastic limit.

### VACUUM DRYING

Dry paper is an excellent insulation for the conductors of a telephone cable, but it must be bone dry. Dry

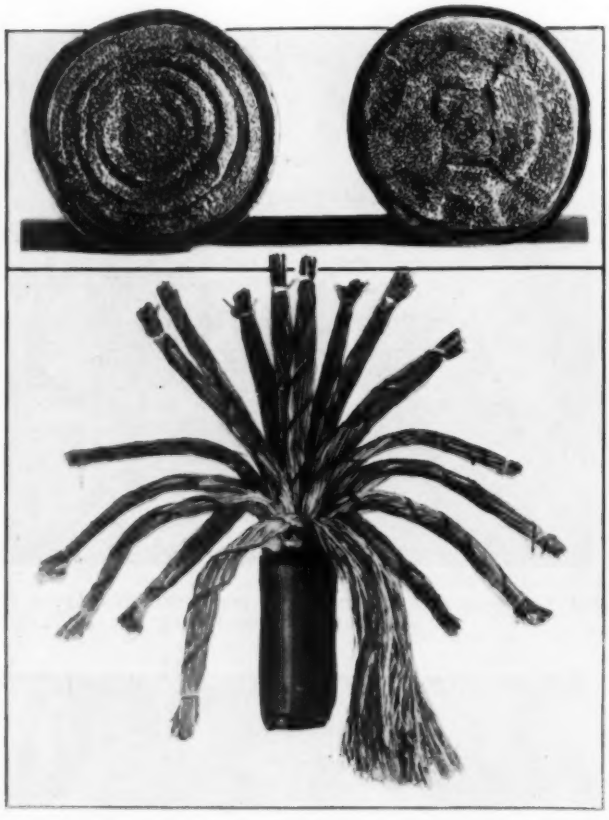

FIG. 8 CABLE CONTAINING 1818 PAIRS OF INSULATED WIRES

paper takes up moisture rapidly, and 1000 lb. loosely packed in a few hours will absorb 90 lb. of moisture in a room at summer temperature and 60 per cent relative humidity.

A vacuum drying operation is applied to stranded cable prior to the lead-sheathing operation at a temperature of 270 deg. fahr. for a period of from 12 to 42 hours, depending on the size of cable. The vacuum toward the end of the drying cycle is less than 2 in. Hg.

The vacuum drying system consists of fifteen horizontal driers, each 40 ft. in length and $7\frac{1}{2}$ ft. in diameter, and one horizontal drier 40 ft. in length and 10 ft. 4 in. in diameter. The former driers are used for the ordinary toll cable, while the latter single tank is used for drying submarine cables of long lengths.

The drying ovens are arranged so that the loading end is located in the cable room proper, and the unloading end in the dehumidified cable storage room. To prevent the exfiltration of dry air from the storage room through joints between oven and brick wall, a novel type of seal is used. This consists of a flexible sheet of copper, to allow for tank expansion, fastened and gasketed on the inner circumference to the tank, and on the outer circumference to the brick wall of the storage oven.

An air-conditioned room is provided for the storage of cable prior to lead sheathing in order to facilitate the covering of varying diameters of cable with a minimum of lead-press die-block changes, and also to act as a reservoir for the fluctuating delivery of large quantities of vacuum-treated cable.

This storage room, approximately 270 ft. long, 50 ft. wide, and 12 ft. high, has been designed to prevent infiltration of moisture. The air-conditioning equipment is unique, in that a relative humidity of 0.5 to 0.8 per cent

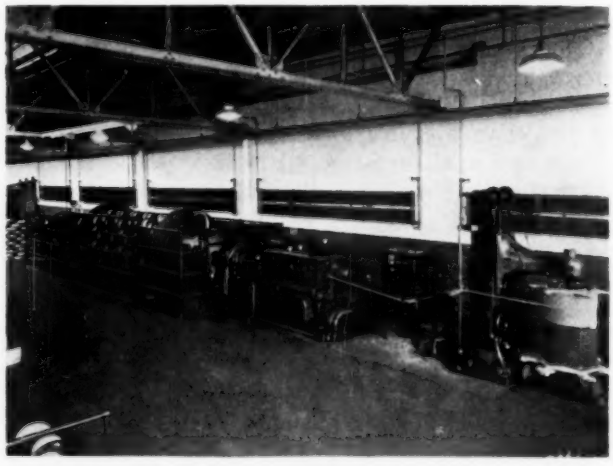

FIG. 9 FLIER STRANDER SERVED BY 101 SUPPLY REELS OF PAIRED WIRE

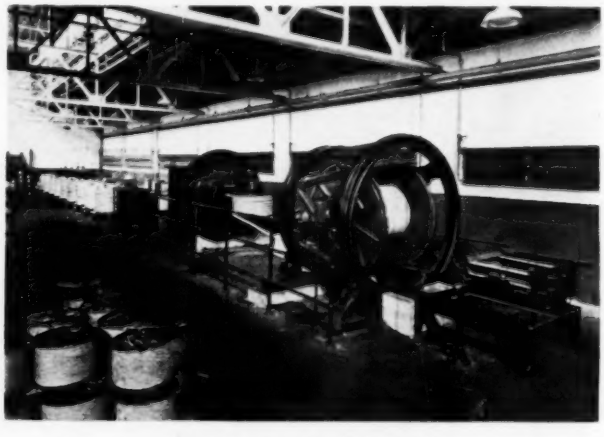

FIG. 10 CABLING MACHINE

is maintained at a temperature of 100 deg. fahr. without resorting to refrigeration.

### LEAD SHEATHING

The thoroughly dried cable core passes from the storage oven through a tube designed to minimize any exposure to outside air, into the press where it receives its protective cover of lead. The basic principle of applying lead sheath to cable is illustrated by Fig. 11, which shows a cross-section of a typical die

block. This die block consists of a core tube and a die, ring shaped, mounted in a hollowed-out block. This arrangement provides an opening adjacent to the cable core which aids in definitely controlling the thickness and diameter of the sheath. This die block is placed underneath a large cylinder for receiving molten lead, and both are placed in a hydraulic press.

The latest type of press used at Baltimore is illustrated by Fig. 12 and is known as the 34-in. inverted press. It was designed and built by one of our outstanding American engineering firms. Its stroke is 56 in.; the diameter of the ram is $10^1/_2$ in., with a lead capacity of 1800 lb. per charge and a maximum extrusion rate of 5680 lb. per hour. (Total pressure during extrusion, 59,000 lb.) This press is approximately 21 ft. in height above the floor line, and has the water cylinder mounted between the four columns at the top of the press. The 34-in.-diameter water ram has the steel lead ram bolted to it. Connection is made from the water cylinder to a hydraulic pump, Fig. 13, supplying water at a maximum pressure of 5500 lb. per sq. in. The four steel columns supporting these top castings are $12^1/_2$ in. in diameter. At the floor level of the press there is a cast-steel plate which carries a steel spacing

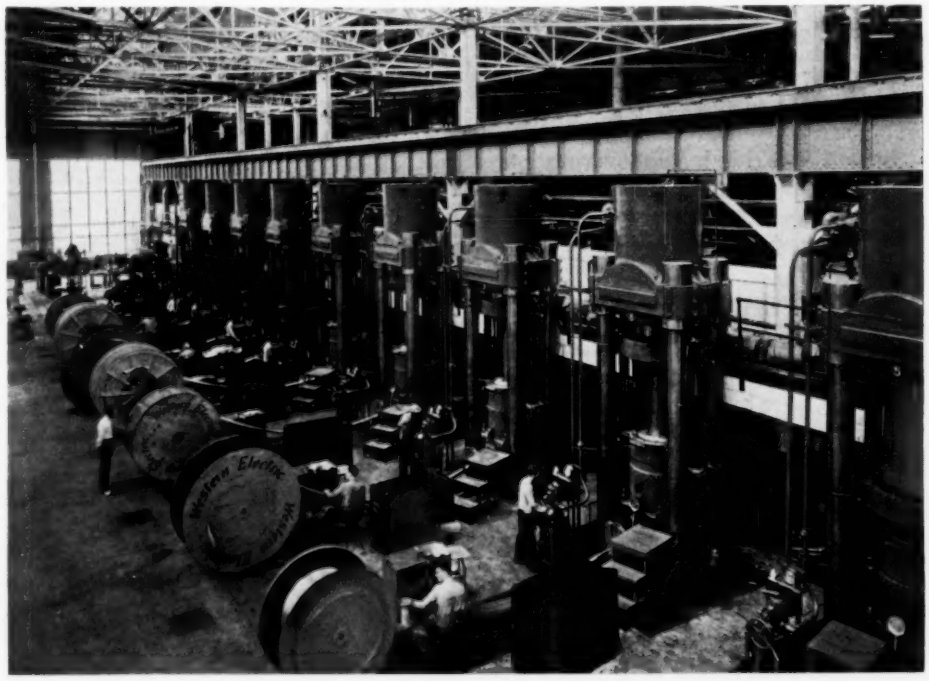

FIG. 12 34-IN. LEAD PRESSES USED IN SHEATHING CABLE

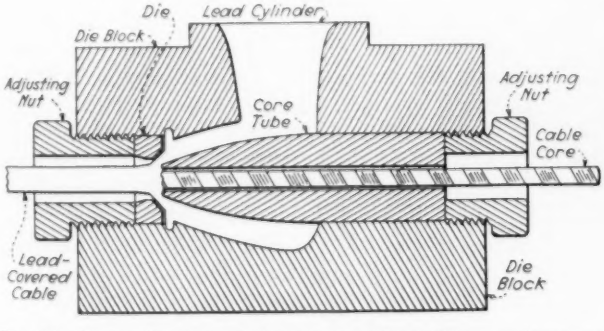


FIG. 11 CROSS-SECTION OF TYPICAL DIE BLOCK USED IN APPLYING LEAD SHEATH TO CABLE

block upon which the die block rests. Above the die block is a water-jacketed lead cylinder which is exactly centered over the feed orifice of the die block. The die block and lead cylinder are held in place on the cast-steel plate by four $2^1/_2$-in. bolts. All these parts are stationary on this press, facilitating handling and inspection, and insuring that the cable core always enters and leaves the die block at the same angle.

The concentricity of the sheath is affected not only by the contour of the extrusion chamber, including core tube and die, but also by the manner in which heat is applied; and the thickness is affected by temperature and speed of extrusion so that the human element is an important factor, and it is necessary to

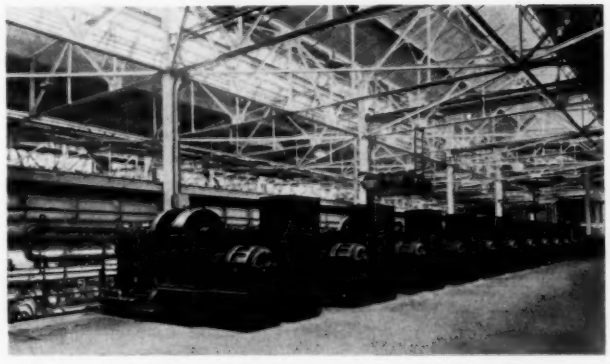

FIG. 13 HYDRAULIC PUMPS USED IN OPERATION OF LEAD PRESSES

have thoroughly trained and reliable operators on this kind of work. Temperature indicators are used to show die-block temperatures, and the temperature of the molten lead is automatically controlled and recorded.

As the lead-covered cable leaves the press it is wound upon either wood or steel reels, depending upon its type. A full reel may weigh as much as 10,000 lb. These reels are rotated by means of power-driven floor rolls which are controlled by the press operator's helper. After the reel was filled with cable, it was

formerly the practice to push the reels off the rolls manually.

The latest type of floor rolls are equipped with automatic ejector devices which lift one roll and cause the loaded reel to roll off on the floor. This is done by means of a small hydraulic cylinder connected to a pump which is operated by a valve mounted adjacent to the floor rolls.

### The Central Lead-Melting System

In order to supply the presses just described, large quantities of lead-antimony alloy must be delivered frequently. With the old arrangement lead was delivered in skids by an overhead traveling crane to small melting kettles adjacent to each pair of presses. This arrangement also involved considerable manual handling, and introduced some variation in the finished alloy sheath.

The new arrangement consists of melting all of the lead alloy in a large furnace at a central location and distributing this molten lead through a long-loop pipe line running back of the presses. Near each press a loop branch from this line is made and equipped with the proper kind of control valve. This line is heated

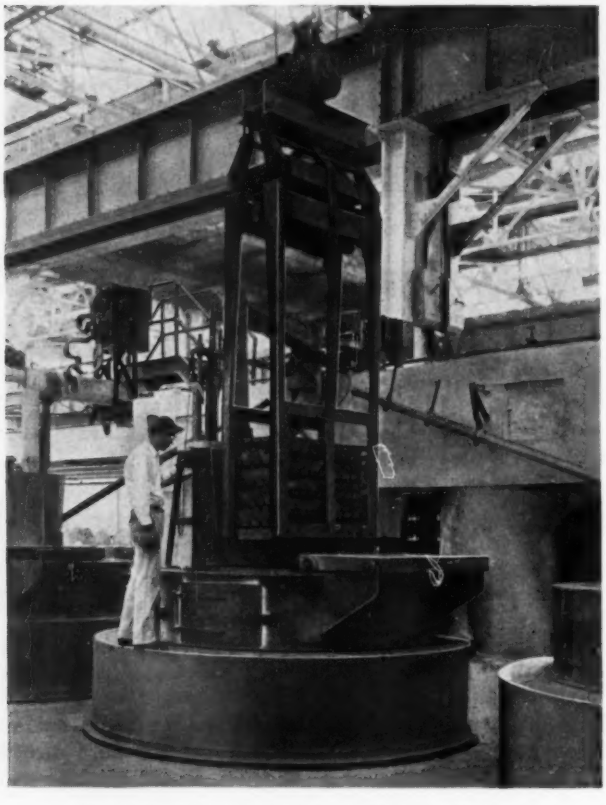

Fig. 14 Charging the Lead-Melting Kettle

electrically and the lead is in constant circulation. In order to take full advantage of such a system, the presses were placed close together, thus saving the space formerly occupied by the small individual melting kettles, and the large central-supply kettles were placed adjacent to the lead storage pit in order to minimize handling. Views of this system now in use at Baltimore are shown in Figs. 14–17.

The details of this central lead-melting and distributing system will be of interest to manufacturers using large quantities of lead or lead alloy. Three oil-heated kettles are used; and pipe and valve arrangements have been set up so that the middle kettle is used for

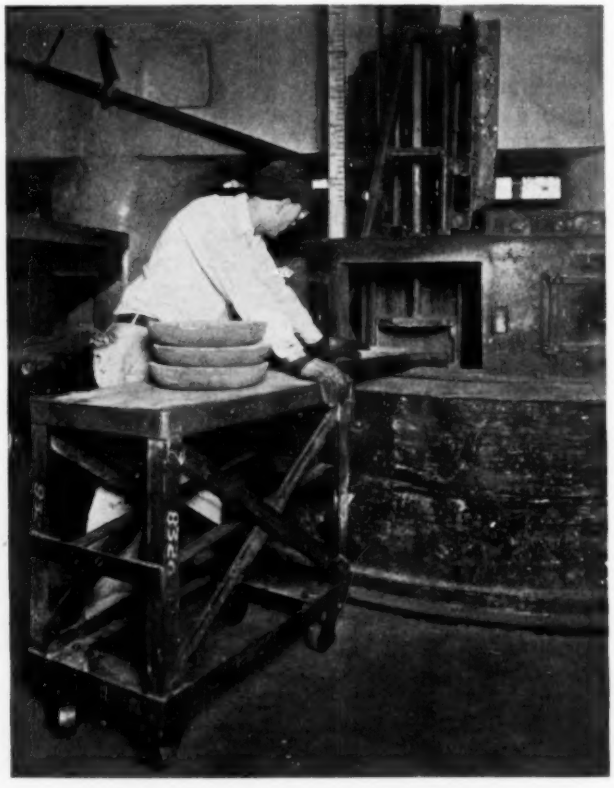

Fig. 15 Antimony-Charging Mechanism

melting and preparing the alloy to the exact composition. The second kettle is used as a main supply and connected up to the distributing system. The third kettle is a spare, and the piping is so arranged that it can be used either as a melting or supply kettle. Each kettle has a capacity of 120,000 lb. of lead, and the melting capacity of the system is 80,000 lb. per hour. Space is provided for a fourth kettle to take care of the ultimate expansion of the cable plant.

Each kettle has two sets of one large and one small low-pressure oil burner installed diagonally across from each other. An impeller type of vertical pump having its intake about 12 in. above the bottom of the kettle, and driven by a 20-hp. vertical motor, creates sufficient agitation by the circulation of the metal to assure a uniform composition.

The charging of the melting kettle with virgin lead is accomplished by means of a specially designed lead-handling grapple, Fig. 14, which has a capacity for 100 billets of the standard size or a total weight of about 8500 lb. Five to six of these charges, or about 40,000 to 50,000 lb., constitutes one melting cycle.

The corresponding amount of antimony is loaded into a special cradle, which moves in a separate chamber and is lowered below the surface of the lead, where the antimony is dissolved by the washing action of the stream of lead from the return line of the pump (see Fig. 15).

The supply kettle is charged with the desired amount of molten lead of the correct composition and temperature from the melting kettle by means of the pump on the transfer line.

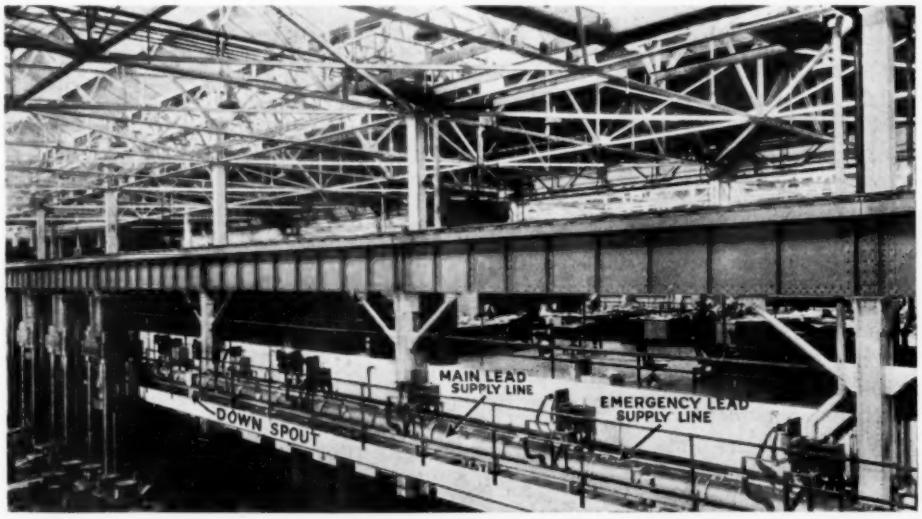


FIG. 16 MAIN LINES SUPPLYING MOLTEN METAL FROM CENTRAL MELTING KETTLE TO LEAD PRESSES

To reduce to a minimum the possibility of a prolonged shutdown due to a breakdown in the lead-conveying line, a duplicate pipe system is provided which can be put into service in a short time in case of failure of the line in use.

The main-line piping system is made of seamless steel tubing supported on a roller-conveyor system to take care of the expansion and contraction, which amounts to $6\frac{1}{2}$ in. per 100 linear feet at 750 deg. fahr., or to a total of approximately 20 in. under normal working conditions for the system. The down spouts are of seamless steel tubing and have a steel valve at each joint with the main line and a service valve at one corner of the U-bend. All joints are oxyacetylene welded, and no fittings are used throughout the system. The lines are insulated with pipe covering protected by a layer of fireproofed canvas (see Fig. 16).

The lines are heated initially by a series of transformers, which supply a low-tension, high-amperage current directly into the pipe by forming a loop of the supply and return line. Once circulation of the lead has been established in the piping system, the main line requires little additional heat from the transformers, as the flow of the lead will ordinarily keep the line up to temperature. Approximately 4 kva. are required on each down spout while in use. The connections leading from the transformer to the pipe are flexible, to allow for expansion and contraction of the system.

This system has been in operation for about nine months and has resulted in a higher quality of lead sheath due to the more uniform composition maintained. In addition there are considerable savings in fuel, a reduction in dross, and the elimination of a large amount of heavy manual effort. The press room is now clean and cool, resulting in much better working conditions and in turn in an indirect improvement in the quality of the product.

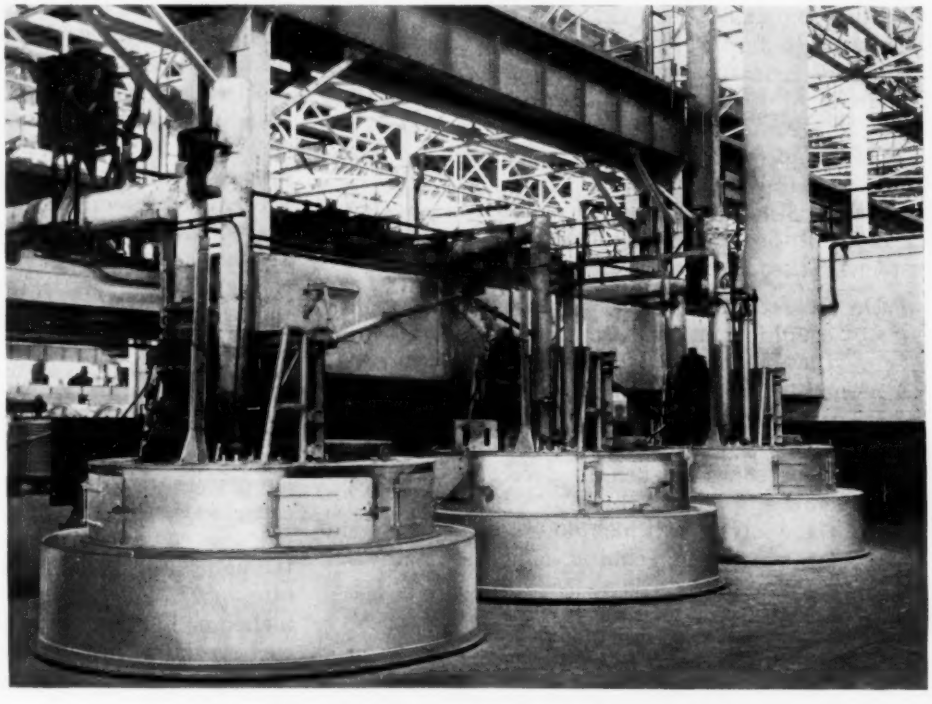

FIG. 17 GENERAL VIEW OF MELTING AND SUPPLY KETTLES

# Experiences and Suggestions Relating to the Preferred-Number System

## Desirability of Adopting a Supplementary Fractional System of Preferred Numbers—Possible Technical Difficulties in Applying a Preferred-Number System—Cases for Standardization Presenting No Particular Technical Difficulties

By R. E. HELLMUND,[1] EAST PITTSBURGH, PA.

VARIOUS papers and discussions on preferred numbers date back quite a number of years, and the table recommended by the American committee was formulated in June, 1927. Considering this, it seems that the progress made in the application of the system and in its popularization has been rather slow. Much of this undoubtedly is due to the difficulty always experienced in displacing deeply rooted existing standards, and to the heavy expense usually involved in a change from one standard to another. Furthermore it seems that in various standardization activities completed since 1927, the deliberations had progressed so far that the committees considered it inadvisable to start all over again in order to introduce the preferred system when it was brought to their attention. These and similar conditions are unavoidable and more or less self-evident, and therefore do not need to be dwelt upon at any length.

It may be helpful, however, to discuss three vital questions in the light of previous experiences with the system. These are:

1 Do the preferred numbers as proposed serve our conditions in the best way possible, or should they be changed or possibly supplemented?

2 Assuming the existence of a satisfactory table or tables, what are some of the technical difficulties in their application, and what steps can be taken to overcome such difficulties?

3 Are there any cases which do not seem to present any particular technical difficulties, and what steps can be taken to stimulate and speed up action in such cases?

In view of the author's connection with the Westinghouse Electric and Manufacturing Company and the fact that its principal activity is in the electrical field, the following discussion will naturally pertain to experiences in this field. However, there is no question that, fundamentally, the same conditions apply in any other field of endeavor.

### Desirability of Adopting a Supplementary Fractional System of Preferred Numbers

With reference to the first question, it may be stated that no particular difficulty has been met with in introducing the proposed system as such wherever the decimal system could be used readily. However, we cannot escape the fact that the fractional system is so deeply rooted in this country that any system based exclusively upon decimals will be adopted very slowly. No matter what one's personal feelings may be regarding the desirability of the use of decimals, one cannot ignore this fact. Even though the engineers and manufacturers may be willing and possibly anxious to adopt the decimal system, we have to concede that there are any number of tradesmen in the country possessing rulers and other measuring equipment based on the fractional system, and unaccustomed to the use of decimals. As a result, the preferred-number system either will not be used at all in many cases, or use may be made of the general principles by changing the decimals to fractions that happen to be most convenient for the case under consideration.

Being convinced of the fundamental soundness of the preferred-number system, the author made various attempts to inject it into the design work of the Westinghouse Electric and Manufacturing Company as well as into the work of the national committees dealing with the standardization of electrical apparatus. One example of this was in connection with the overall and mounting dimensions of electrical machines. In this and in other cases there was at once a rather marked reaction against the use of decimals for this purpose. The manufacturers might have been converted to the use of decimals, but the committees representing the users were definitely opposed to it.

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Abstract of a paper presented at the annual meeting of the American Standards Association, New York, December 11, 1930.

Unquestionably there was some justification for their position, because the mounting of machines and apparatus is not merely a factory proposition but one which has to be handled in the field by a great variety of personnel used to the fractional system. Because of this reaction, Mr. R. Ehrenfeld[2] worked out a fractional preferred-number system (see Table 1), which

TABLE 1 SUGGESTED FRACTIONAL PREFERRED NUMBERS—1 TO 100

| 5 Series | 10 Series | 20 Series | 40 Series | 5 Series | 10 Series | 20 Series | 40 Series |
|---|---|---|---|---|---|---|---|
| 1 | 1 | 1 | 1 | 10 | 10 | 10 | 10 |
| .. | .. | .. | 1 1/16 | .. | .. | .. | 10 1/2 |
| .. | .. | 1 1/8 | 1 1/8 | .. | .. | 11 | 11 |
| .. | .. | .. | 1 3/16 | .. | .. | .. | 11 3/4 |
| .. | 1 1/4 | 1 1/4 | 1 1/4 | .. | 12 1/2 | 12 1/2 | 12 1/2 |
| .. | .. | .. | 1 5/16 | .. | .. | .. | 13 1/4 |
| .. | .. | 1 3/8 | 1 3/8 | .. | .. | 14 | 14 |
| .. | .. | .. | 1 15/32 | .. | .. | .. | 15 |
| 1 9/16 | 1 9/16 | 1 9/16 | 1 9/16 | 16 | 16 | 16 | 16 |
| .. | .. | .. | 1 17/32 | .. | .. | .. | 17 |
| .. | .. | 1 3/4 | 1 3/4 | .. | .. | 18 | 18 |
| .. | .. | .. | 1 7/8 | .. | .. | .. | 19 |
| .. | 2 | 2 | 2 | .. | 20 | 20 | 20 |
| .. | .. | .. | 2 1/8 | .. | .. | .. | 21 |
| .. | .. | 2 1/4 | 2 1/4 | .. | .. | 22 | 22 |
| .. | .. | .. | 2 3/8 | .. | .. | .. | 23 1/2 |
| 2 1/2 | 2 1/2 | 2 1/2 | 2 1/2 | 25 | 25 | 25 | 25 |
| .. | .. | .. | 2 5/8 | .. | .. | .. | 26 1/2 |
| .. | .. | 2 3/4 | 2 3/4 | .. | .. | 28 | 28 |
| .. | .. | .. | 2 15/16 | .. | .. | .. | 30 |
| .. | 3 1/8 | 3 1/8 | 3 1/8 | .. | 32 | 32 | 32 |
| .. | .. | .. | 3 3/16 | .. | .. | .. | 34 |
| .. | .. | 3 1/2 | 3 1/2 | .. | .. | 36 | 36 |
| .. | .. | .. | 3 3/4 | .. | .. | .. | 38 |
| 4 | 4 | 4 | 4 | 40 | 40 | 40 | 40 |
| .. | .. | .. | 4 1/4 | .. | .. | .. | 42 |
| .. | .. | 4 1/2 | 4 1/2 | .. | .. | 44 | 44 |
| .. | .. | .. | 4 3/4 | .. | .. | .. | 47 |
| .. | 5 | 5 | 5 | .. | 50 | 50 | 50 |
| .. | .. | .. | 5 1/4 | .. | .. | .. | 53 |
| .. | .. | 5 1/2 | 5 1/2 | .. | .. | 56 | 56 |
| .. | .. | .. | 5 7/8 | .. | .. | .. | 60 |
| 6 1/4 | 6 1/4 | 6 1/4 | 6 1/4 | 64 | 64 | 64 | 64 |
| .. | .. | .. | 6 5/8 | .. | .. | .. | 68 |
| .. | .. | 7 | 7 | .. | .. | 72 | 72 |
| .. | .. | .. | 7 1/2 | .. | .. | .. | 76 |
| .. | 8 | 8 | 8 | .. | 80 | 80 | 80 |
| .. | .. | .. | 8 1/2 | .. | .. | .. | 84 |
| .. | .. | 9 | 9 | .. | .. | 88 | 88 |
| .. | .. | .. | 9 1/2 | .. | .. | .. | 94 |
| 10 | 10 | 10 | 10 | 100 | 100 | 100 | 100 |

was subsequently instrumental in the use of the preferred-number idea for several cases.

In view of conditions previously stated and of the experiences just related, the author believes that the Committee on Preferred Numbers should seriously consider the adoption of a fractional system in addition to the decimal system, but that continued emphasis should be given to the preferment of the decimal system over the fractional system. The establishing of a fractional system seems desirable so that those insisting upon fractions will have a common ground and not be obliged to evolve several similar but slightly different systems. As to whether the fractional system suggested by Mr. Ehrenfeld is the best all-round system and whether it should be extended below one inch, the author is not prepared to say. This should be carefully studied by the Committee, and it may furthermore be advisable to study the relation between the decimal and fractional systems with the idea of making them coincide as far as possible.

## Possible Technical Difficulties in Applying Preferred-Number System

Our second question relates to the technical difficulties which may be encountered in applying the preferred-number system. Among these there are two outstanding ones:

*a* Space, weight, or similar limitations

*b* The interrelation of many dimensions, making it difficult to standardize on a preferred-number series for more than a few of them in a given design.

The question of space limitations can be illustrated by the induction motor shown in Fig. 1. Let us assume that the various manufacturers have agreed among themselves that $11\frac{1}{8}$ in. is the smallest dimension for $L$ within which they all can keep and at the same time obtain satisfactory performance for a certain definite rating. In order, then, to bring this dimension within the fractional preferred-number system, it would have to be increased to $11\frac{3}{4}$ in. Even though the increase is less than 6 per cent, it may be rightfully questioned whether such an increase in the space requirements for no other purpose than that of being in line with a preferred-number system would be

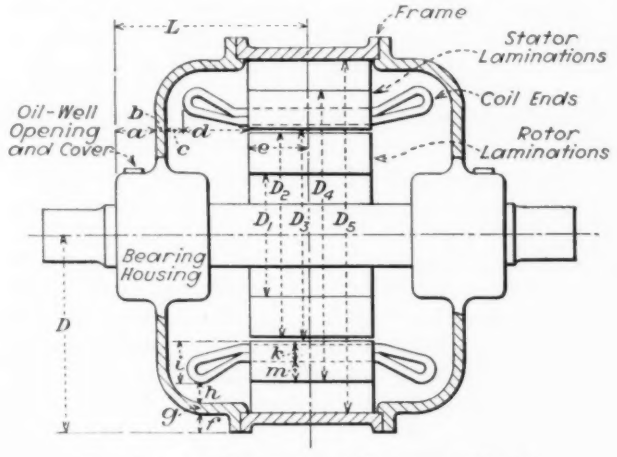


FIG. 1 CROSS-SECTION OF AN INDUCTION MOTOR

justified from an economic point of view. Assuming this to be answered in the negative, the question then arises as to whether by special efforts and possibly by some sacrifice in performance the dimension could be shortened to meet the next smaller preferred number. Since the necessary reduction of $\frac{1}{8}$ in. is but slightly more than one per cent of the dimension under consideration, this would on first thought appear to be rather easy. We find, however, that with the dimensions *a*, *b*, *c*, and *d* assumed to be reduced to the minimum in line with safe practice, a reduction would have to be made in the core width *e*. This dimension in a practical case might be in the neighborhood of $1\frac{1}{2}$ to 2 in., and so the reduction of $\frac{1}{8}$ in. would be from 6 to 8 per cent, which in turn is rather appreciable and might affect the motor performance quite materially.

Nevertheless the author believes that the dimensions under discussion could be arranged to be in the preferred-number series. The reason for this is that

[2] Asst. Mgr., Small-Motor Engineering Dept., Westinghouse Elec. & Mfg. Co., East Pittsburgh, Pa.

any one of the standardized frames is never used for a single rating but covers a great variety of ratings, such as continuous and short-time ratings, various speed and frequencies, so-called Class I and Class II motors for different starting conditions, and many others. It is an obvious and fully established fact that so many ratings on a given frame cannot all be obtained ideally by any one value for a certain dimension. In other words, any dimension chosen for $L$ would favor some of the ratings and unfavorably affect others. Therefore, when looking at this matter broadly, there is little doubt that a preferred number for dimension $L$ would serve the industry fully as well as the dimension of $11^1/_8$ in. discussed. In fact, better all-round results could probably be obtained with the use of preferred numbers for this dimension, as this would bring about more logical steps between the various standard frames.

This same condition applies to the great majority of cases, and a design is very seldom carried through for one specific rating or condition. Even if such were the case now and then, conditions are likely to change very quickly on account of improvements in materials used, additional design knowledge or skill, improved manufacturing conditions, etc. This means that even if the most favorable conditions with reference to size and space were realized today, they are likely to be obsolete tomorrow, and so for this reason the choice of a preferred number will very seldom impose a permanent handicap upon the industry with regard to space limitations and the like. However, it must be granted that there are some special cases, as in railway work, where space limitations are very exacting. Here it is very often desirable to obtain the maximum rating possible in a given space regardless of other conditions, and such considerations are more important than being in line with a preferred-number system.

More frequently difficulties present themselves in the general application of a preferred-number system due to the interrelation of various dimensions in certain designs. For instance, in induction motors it would be exceedingly desirable to standardize on the diameters $D_1$, $D_2$, $D_3$, and $D_4$ (Fig. 1) for the laminations of the stator and the rotor. The reason for this is that the manufacturers are continuously expending appreciable amounts of money for punching dies for various diameters. An attempt was therefore made to bring such diameters in line with the preferred-number system—so far, however, with practically no results because of the following conditions: The largest inside diameter of the stator which is possible is essentially fixed by the previously standardized dimension $D$ and the fact that the dimensions $f$, $g$, $h$, and $i$ cannot be reduced advantageously or safely below certain values. Therefore, in order to bring $D_3$ to the nearest preferred number, it would have to be decreased in some cases as much as 5 to 6 per cent below the possible maximum even with the use of the 40 series. Since with smaller motors the rating varies in proportion to more than the square of the diameter, this would mean that a rating reduction as great as 15 per cent might be involved, or else the performance of the motor would be seriously affected. (The use of the 80 series would improve this condition, but it would introduce so many standard diameters that it would largely defeat the purpose of standardization.) Thus the designer trying to adopt the preferred-number system would handicap himself considerably in competition with a designer not so limiting himself. Then, again, if the inside diameter of the stator were chosen to be a preferred number, the outside diameter $D_2$ of the rotor could not be so chosen because the air gap of induction motors is in all cases smaller than the smallest step in any reasonable series. The outside diameter of the stator punchings, $D_4$, is usually determined by making $k$ and $m$ as small as possible. The choosing of a diameter larger than necessary in order to meet the next larger preferred number would frequently

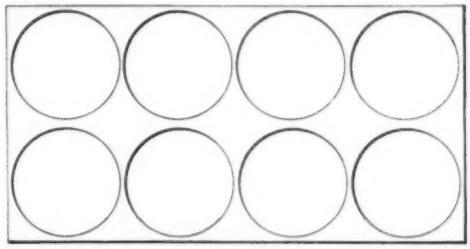

FIG. 2 SHEET STEEL BLANK FOR STATOR PUNCHINGS

be satisfactory from a design point of view, but it would necessitate the use of larger sheets from which the punchings are made (Fig. 2). This in turn would frequently lead to an economic waste not justified by the advantages of living up to the preferred-number system and the reduction in tool expense which would result therefrom.

Another point entering into this general problem is the desirability of adopting preferred numbers for the sheet sizes from which these punchings are made (Fig. 2). Under practically all conditions it was found that if the outside diameter $D_4$ were chosen from the preferred series the sheets from which the punchings were made could not be from that series without involving an undesirable amount of scrap. Quite an extensive study would be necessary to determine which of the two factors should be given preference in order to obtain the maximum economy.

Nevertheless cases like this may not be entirely hopeless, and may be worth while considering when undertaken under somewhat more favorable conditions. The question of punching diameters also enters into the design of commutating and synchronous machines, where the interrelation of punching dimensions is not quite so involved. Fig. 3 shows a number of curves in which the diameters of the punchings are plotted on semilogarithmic paper, both for some older lines and for some lines which have been brought out since the advantages of the geometric series were appreciated.

It will be seen from these curves and points that it is possible to follow a geometric series to good advantage. Even the newer lines shown here are not in accord with the preferred series, but this is due to the fact that certain dimensions had been previously settled and that the advantages which could be gained with the standard preferred numbers were not sufficient from an economic point of view to counterbalance the losses involved in scrapping existing tools and making obsolete the existing drawings and experience.

The induction-motor condition described is of course rather involved, but it is a good illustration of the

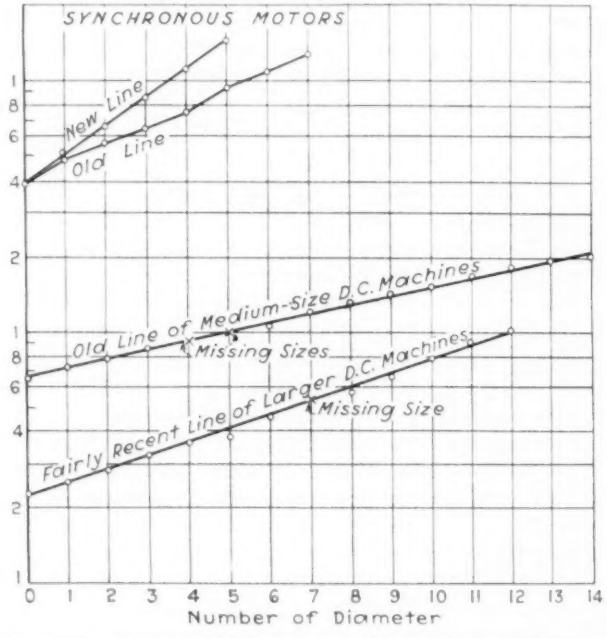


FIG. 3 DIAMETERS OF PUNCHINGS FOR VARIOUS LINES OF MOTORS

many problems introduced by the interrelation between the dimensions in design work. Similar questions arise, however, in many much simpler cases. It is at once evident, for instance, that in the case of a bolt in a clearance hole (Fig. 4), it will be impossible to have both the hole and the bolt on a preferred-number basis without making the clearance excessive, although good reasons can be advanced why either of the two dimensions could be standardized to good advantage on a preferred-number basis. Again, when it comes to finished materials, the question arises whether the finished article or the unfinished stock sizes should be chosen from the preferred series; too much stock would have to be machined off in many cases if both of the dimensions were chosen from the series. Even the question of tolerances enters into the problem.

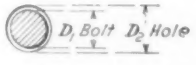


FIG. 4 BOLT IN CLEARANCE HOLE

What conclusions can now be drawn from these previous considerations? One thing is most evident, and that is that the engineer is not confronted merely with the problem of adopting the series, but first of all with the necessity of studying carefully which of the dimensions in a given design should be chosen from the series in order to accomplish the maximum economic results. Then, too, wherever there is hope of having several of the dimensions from the preferred series, he must decide which of them should be chosen first. In the foregoing example of an induction motor, it might have been possible to start out with the punching diameters, and subsequently to have standardized on the mounting dimensions with less handicap to the final result than was obtained with the reverse procedure.

In view of all of this, the author feels that for the present it may not be advisable to urge too strongly the quick adoption of the preferred-number system in a great many instances. He believes, however, that a great deal could be accomplished toward the final result if it were suggested to the various standardization agencies that they study first of all which dimensions in their products, if any, could preferably be based on the preferred-number system. Such studies carried on by the various standardization bodies would assist greatly in spreading the idea of preferred numbers, and facilitate their adoption when an opportune time presents itself.

## CASES FOR STANDARDIZATION PRESENTING NO PARTICULAR TECHNICAL DIFFICULTIES

The third question is that of whether there are any cases subject to preferred-number standardization which do not present great technical difficulties. It seems to the author that there are a great number of such cases in connection with nominal ratings of machinery and apparatus. In the standardization of ratings we do not run into the difficulties presented by the parallel use of decimals and fractions, and can without any great difficulty apply the decimal system. Furthermore the interrelation of figures met with in dimensions is present only in exceptional cases where ratings are concerned. Referring again to the standardization of electrical motors, Table 2 shows the present standard ratings and also the nearest figures in the 5 series up to 16 hp., and from there on in the 10 series. The 5 and 10 series as indicated gives one less rating over the same range and, in spite of this, less maximum spacing between the ratings. In the lower range of the present standards the maximum spacing is 66.6 per cent, while with the 5 series it is 60 per cent. In the upper range the maximum spacing of the present standards is 33 per cent, while with the 10 series it would be only 25 per cent. There might be some question as to whether ratings such as

TABLE 2 LARGE-MOTOR HORSEPOWER RATINGS

| Present Standards | 5 Series | 10 Series |
|---|---|---|
| 1 | 1 | .. |
| 1.5 | 1.6 | .. |
| 2 | 2.5 | .. |
| 3 | 4.0 | .. |
| 5 | .. | .. |
| 7.5 | 6.4 | .. |
| 10 | 10 | .. |
| 15 | 16 | .. |
| 20 | .. | 20 |
| 25 | .. | 25 |
| 30 | .. | 32 |
| 40 | .. | 40 |
| 50 | .. | 50 |
| 60 | .. | 64 |
| 75 | .. | 80 |
| 100 | .. | 100 |
| 125 | .. | 125 |
| 150 | .. | 160 |
| 200 | .. | 200 |

16 hp. could be as readily adopted as 15 hp. In this connection reference might be made to the ratings of the old carbon lamps, where the rating of 16 candlepower was in use for many years. It is needless to say that the standardization of horsepower ratings on a preferred-number basis can also be applied to gasoline engines, Diesel engines, steam engines, steam turbines, etc., whenever new standardizations are undertaken. The use of the system should further be advocated in the case of watts, kilowatts, and kilovolt-amperes as relating to such apparatus as lamps, generators, transformers, etc. In a-c. generators there is an interrelation of ratings due to the fact that they are rated on both a kilowatt and a kilovolt-ampere basis. However, there is some leeway in the power factor on which the kva. ratings can be based, and if it is made a practice to base the kva. ratings on power-factor values approximating the 10 and 20 series, it will be found possible to base both the kw. and kva. ratings for the same machine on the preferred-number system. It so happens that the standard power factor used for ratings by the N.E.M.A. is 0.8, a figure which is in the 10 series. This eliminates any difficulty in having both the kw. and kva. ratings in the preferred-number series.

Similarly, it is found that transformers of various kinds could be readily rated by the use of the 5 and 10 series.

Table 3 shows the lamp ratings as at present standardized compared with the possible preferred-number ratings. It will be noted that the best choice for the latter first follows the 5 series; then for some distance, covering the more popular ratings for lamps, it follows the 10 series; and finally, for the less popular high ratings, goes back to the 5 series.

TABLE 3 LAMPS

| Standard Watts | 5 Series | 10 Series |
|---|---|---|
| 15 | 16 | .. |
| 25 | 25 | .. |
| 40 | 40 | .. |
| 50 | .. | 50 |
| 60 | .. | 64 |
| 75 | .. | 80 |
| 100 | .. | 100 |
| .. | .. | 125 |
| 150 | .. | 160 |
| 200 | .. | 200 |
| .. | 250 | .. |
| 300 | .. | .. |
| .. | 400 | .. |
| 500 | 640 | .. |
| 750 | .. | .. |
| 1000 | 1000 | .. |

Considerable advantage, without any undue technical difficulties, would result from the use of the preferred-number system for the standardization of current ratings on all series-connected apparatus. Examples of this type of apparatus that may be mentioned are magnetic contactors, small air circuit breakers, large circuit breakers of various types, fuses, thermal cut-outs, knife and disconnecting switches, snap switches, watthour meters, current transformers, etc.

A comparison of the present standard ratings for these devices with the 5 and 10 series indicates that no difficulty would be encountered in using these series for the ratings in future standardization activities. Nearly always the addition or elimination of one or two of the steps in the entire range of ratings and the use of the series would bring about lines with uniform steps smaller than the maximum steps in the present standards. There may be some doubt regarding the use of the standard series for the thermal cut-outs. The present ratings follow a geometric series with steps of about 20 per cent. As to whether it would be possible to change to the 10 series with steps of 25 per cent and at the same time adequately protect the motors with which these thermal cut-outs are used, would have to be carefully investigated. On the other hand, the use of the 20 series would mean an appreciable increase in the number of ratings. This therefore represents one case in which the advisability of adopting the preferred-number series is doubtful, although a geometric series is now used to good advantage.

A change to the preferred-number system for the current ratings of series-connected apparatus would result in the obvious advantage of having all such apparatus rated on the same basis; in fact, the preferred-number system seems to be the most promising vehicle for bringing the various committees and manufacturers together.

The author wishes to emphasize that he is not advocating an immediate adoption of preferred numbers for all these purposes, because the advantages gained thereby would not be sufficient to outweigh the disadvantages in upsetting existing standards and the expense involved in so doing. However, changes in standards are continually taking place for other reasons, and whenever this is the case, changing to the preferred series should always be considered. It also seems possible that whenever a complete revision of a line is not advisable at any one time, a gradual working toward the preferred series could frequently be accomplished. In many of the cases studied, a change of one or two ratings would be sufficient to bring the whole line, or at least the greater part of it, substantially in accord with the preferred-number series.

Although the examples previously cited relate to the electrical industry, the author has no doubt that similar standardizations could be accomplished in other industries. For example, the capacities of blowers and pumps, and possibly also the pressure ratings, could be based on the preferred-number series.

In order to bring all this about whenever suitable opportunities present themselves, it would be necessary to interest the various standardization committees in the possibilities just cited. One definite suggestion is that each of the interested committees be requested to appoint one member to study the possibility of adopting preferred numbers for ratings. In the case of electrical-current ratings, which enter into the work of a great many committees, it could probably be arranged to have these especially appointed members of the various committees meet for the purpose of discussing the advantages of eventually adopting preferred numbers. The author is convinced that considerable progress would be made if these and similar steps were taken in the near future, as in this way all of the committees interested would have the question of preferred numbers brought to their attention whenever new standardizations were under consideration.

# The Second International Steam-Table Conference—Skeleton Steam Tables

THE Second Steam-Table Conference was held in Berlin during the week commencing June 23, 1930, in continuation of the First Conference held in London in July, 1929, and reported in the February, 1930, issue of MECHANICAL ENGINEERING, p. 120. It was convened by the Verein deutscher Ingenieure, and there were present the following:

*United States of America*

DR. H. N. DAVIS, Hoboken, N. J.
DR. H. C. DICKINSON, Washington, D. C.
PROF. J. H. KEENAN, Hoboken, N. J.
DR. F. G. KEYES, Cambridge, Mass.
G. A. ORROK, New York, N. Y.
DR. N. S. OSBORNE, Washington, D. C.
C. B. LE PAGE, New York, Secretary to the American Delegation.

*Great Britain*

G. S. CALLENDAR, London
J. P. CHITTENDEN, Rugby
R. DOWSON, Newcastle
A. EGERTON, F.R.S., Oxford
H. L. GUY, Manchester
B. POCHOBRADSKY, London
I. V. ROBINSON, London
F. SAMUELSON, Rugby
DR. G. STONEY, F.R.S., Newcastle
D. V. ONSLOW, London, Secretary to the British Delegation.

*Czechoslovakia*

DR. J. HAVLICEK, Witkowitz
PROF. L. MISKOVSKY, Prag

*Germany*

DIPL.-ING. W. FRITZ, Berlin
DR. H. HAUSEN, Munich
PROF. DR. FR. HENNING, Berlin
PROF. DR. M. JAKOB, Berlin
PROF. DR. O. KNOBLAUCH, Munich
DR. W. KOCH, Munich
PROF. DR. R. MOLLIER, Dresden
PROF. DR. W. NERNST, Berlin
DIPL.-ING. C. HÖHNER, Berlin, Secretary to the German Delegation.

*Sweden*

I. V. BLOMQUIST, Stockholm

*Switzerland*

PROF. DR. G. EICHELBERG, Zurich.

The Conference was opened on Monday, June 23, by Prof. Dr. C. Matschoss, Director of the Verein deutscher Ingenieure, who in his introductory remarks referred feelingly to the loss sustained by the Conference through the death of Prof. H. L. Callendar, F.R.S. The proceedings then continued under the chairmanship of Prof. Dr. W. Nernst.

After the necessary formal business had been completed, it was decided, as in London in 1929, to form a small committee to consider the actual revision of the values and enlargement of the skeleton tables. This committee consisted of the following representatives of the different delegations:

*United States of America*

DR. H. C. DICKINSON
PROF. J. H. KEENAN
DR. F. G. KEYES
DR. N. S. OSBORNE

*Great Britain*

G. S. CALLENDAR
A. EGERTON, F.R.S.
I. V. ROBINSON

*Germany*

DR. H. HAUSEN
PROF. DR. M. JAKOB

*Czechoslovakia*

PROF. L. MISKOVSKY

Mr. I. V. Robinson was later elected chairman of the Committee.

Some meetings of the Committee were also attended by Mr. Blomquist and Prof. Dr. Eichelberg, and also by other members of the various delegations.

The Committee held five meetings, and reported to the final Plenary Meeting of the Conference on the forenoon of Thursday, June 26.

Using the 1929 skeleton steam tables as a basis, the Committee had revised these tables by the consideration of new experimental data, concerning which the different investigators had submitted short reports.

Thus the table of properties of saturated steam had been enlarged by including values for the properties of saturated water and steam at temperatures of 275 and 325 deg. cent.; and in the table of the properties of superheated steam, values of the specific volume and total heat had been inserted for temperatures of 150, 250, and 350 deg. cent.

The additional experimental data available have thus made it possible to enlarge the skeleton tables so that they may serve as a more complete check to working tables prepared for the use of engineers.

The tolerances, which are still retained, permit flexibility in formulations made to serve as the basis for calculating complete working tables of the properties of steam.

In some instances smaller tolerances would have been justified by the close agreement of the different investigators, but it was deemed advisable not to reduce them too much at the present time, but to retain ample tolerances until such time as the various in-

## SATURATED STEAM—ASSUMED VALUES AND TOLERANCES

### SATURATION PRESSURE AND SPECIFIC VOLUME

| Temperature, deg. cent. | Saturation pressure: Assumed value, kg. per sq. cm. | Saturation pressure: Tolerance, (±) kg. per sq. cm. | Specific volume: Of liquid: Assumed value, cu. m. per kg. | Specific volume: Of liquid: Tolerance, (±) cu. m. per kg. | Specific volume: Of vapor: Assumed value, cu. m. per kg. | Specific volume: Of vapor: Tolerance, (±) cu. m. per kg. |
|---|---|---|---|---|---|---|
| 0 | 0.006225 | 0.000005 | 0.001000 | 0.000000 | 206.4 | 0.2 |
| 50 | 0.1258 | 0.0001 | 0.001012 | 0.000000 | 12.05 | 0.01 |
| 100 | 1.0332 | 0.0000 | 0.001043 | 0.000000 | 1.673 | 0.002 |
| 150 | 4.855 | 0.003 | 0.001090 | 0.000000 | 0.392 | 0.001 |
| 200 | 15.86 | 0.01 | 0.001156 | 0.000001 | 0.1273 | 0.0004 |
| 250 | 40.6 | 0.1 | 0.001252 | 0.000003 | 0.0502 | 0.0004 |
| 275 | 60.7 | 0.1 | 0.001317 | 0.000004 | 0.0329 | 0.0005 |
| 300 | 87.7 | 0.1 | 0.001403 | 0.000005 | 0.0215 | 0.0005 |
| 325 | 123.0 | 0.1 | 0.00153 | 0.00001 | 0.0142 | 0.0004 |
| 350 | 168.7 | 0.15 | 0.00174 | 0.00001 | 0.00875 | 0.00020 |

### TOTAL HEAT

| Temperature, deg. cent. | Total heat: Of liquid: Assumed value, Int. kg-cal. per kg. | Total heat: Of liquid: Tolerance, (±) Int. kg-cal. per kg. | Total heat: Of vapor: Assumed value, Int. kg-cal. per kg. | Total heat: Of vapor: Tolerance, (±) Int. kg-cal. per kg. |
|---|---|---|---|---|
| 0 | 0 | 0 | 595.5 | 1.0 |
| 50 | 49.95 | 0.02 | 618.5 | 1.0 |
| 100 | 100.04 | 0.04 | 639.2 | 0.5 |
| 150 | 150.92 | 0.05 | 656.0 | 1.5 |
| 200 | 203.55 | 0.10 | 667.0 | 2.5 |
| 250 | 259.2 | 0.5 | 669 | 4 |
| 275 | 289.0 | 1.0 | 666 | 5 |
| 300 | 322 | 2 | 657 | 5 |
| 325 | 360 | 3 | 643 | 6 |
| 350 | 404 | 5 | 615 | 8 |

vestigators are in still closer agreement over the whole of the field covered by the skeleton tables.

The 1929 skeleton tables are superseded entirely by those attached to this report.

### UNITS

As in the 1929 tables, the following units have been used:

| | Unit | Symbol |
|---|---|---|
| Length | Meter | m. |
| Specific volume | Cubic meters per kilogram | cu. m. per kg. |
| Pressure | Kilograms per square centimeter | kg. per sq. cm. |
| Temperature | Degree centigrade | deg. cent. |
| Total heat | International kilo-calorie, which by definition equals 1 kw-hr./860 | kg-cal. per kg. |

### CONVERSION FACTORS

No changes have been made in the values of the various conversion factors adopted at London and fully detailed in the 1929 report.

### VALUES BY DEFINITION

Two values given in the skeleton steam tables are taken as exact by definition and therefore no tolerances are permissible. These values are for the total heat of saturated water under its own vapor at 0 deg. cent., arbitrarily taken as equal to zero, and the pressure of saturated steam at 100 deg. cent., which is, by definition, equal to $1.01325 \times 10^6$ dynes per sq. cm. (1.0332 kg. per sq. cm.) in the specifications of the International Temperature Scale.

## SUPERHEATED STEAM—ASSUMED VALUES AND TOLERANCES

### SPECIFIC VOLUME

| Temperature, deg. cent. | Assumed value, cu. m. per kg. | Tolerance, (±) cu. m. per kg. | Assumed value, cu. m. per kg. | Tolerance, (±) cu. m. per kg. | Assumed value, cu. m. per kg. | Tolerance, (±) cu. m. per kg. |
|---|---|---|---|---|---|---|
| | Pressure: 1 kg. per sq. cm. | | Pressure: 5 kg. per sq. cm. | | Pressure: 10 kg. per sq. cm. | |
| 100 | 1.730 | 0.003 | ..... | ..... | ..... | ..... |
| 150 | 1.974 | 0.003 | ..... | ..... | ..... | ..... |
| 200 | 2.214 | 0.003 | 0.4332 | 0.0005 | 0.2102 | 0.0003 |
| 250 | 2.452 | 0.003 | 0.4833 | 0.0005 | 0.2374 | 0.0003 |
| 300 | 2.689 | 0.004 | 0.5326 | 0.0005 | 0.2631 | 0.0003 |
| 350 | 2.925 | 0.004 | 0.5811 | 0.0005 | 0.2880 | 0.0003 |
| 400 | 3.161 | 0.005 | 0.6290 | 0.0005 | 0.3124 | 0.0003 |
| 450 | 3.396 | 0.005 | 0.6768 | 0.0005 | 0.3366 | 0.0003 |
| 500 | 3.632 | 0.005 | 0.7243 | 0.0005 | 0.3604 | 0.0004 |
| 550 | 3.868 | 0.005 | 0.7719 | 0.0005 | 0.3843 | 0.0005 |
| | Pressure: 25 kg. per sq. cm. | | Pressure: 50 kg. per sq. cm. | | Pressure: 100 kg. per sq. cm. | |
| 250 | 0.0890 | 0.0003 | ..... | ..... | ..... | ..... |
| 300 | 0.1010 | 0.0003 | 0.0465 | 0.0004 | ..... | ..... |
| 350 | 0.1120 | 0.0003 | 0.0531 | 0.0004 | 0.0231 | 0.0005 |
| 400 | 0.1224 | 0.0003 | 0.0590 | 0.0003 | 0.0270 | 0.0005 |
| 450 | 0.1325 | 0.0003 | 0.0644 | 0.0003 | 0.0304 | 0.0004 |
| 500 | 0.1424 | 0.0004 | 0.0697 | 0.0004 | 0.0333 | 0.0005 |
| 550 | 0.1521 | 0.0005 | 0.0747 | 0.0005 | 0.0361 | 0.0005 |
| | Pressure: 150 kg. per sq. cm. | | Pressure: 200 kg. per sq. cm. | | Pressure: 250 kg. per sq. cm. | |
| 350 | 0.0119 | 0.0005 | ..... | ..... | ..... | ..... |
| 400 | 0.0160 | 0.0005 | 0.01028 | 0.00005 | 0.00636 | 0.00005 |
| 450 | 0.0189 | 0.0004 | 0.01305 | 0.00030 | 0.00940 | 0.00015 |
| 500 | 0.0212 | 0.0004 | 0.01515 | 0.00035 | 0.01140 | 0.00025 |
| 550 | 0.0233 | 0.0005 | 0.01685 | 0.00040 | 0.01290 | 0.00040 |

### TOTAL HEAT

| Temperature, deg. cent. | Assumed value, Int. kg-cal. per kg. | Tolerance, (±) Int. kg-cal. per kg. | Assumed value, Int. kg-cal. per kg. | Tolerance, (±) Int. kg-cal. per kg. | Assumed value, Int. kg-cal. per kg. | Tolerance, (±) Int. kg-cal. per kg. |
|---|---|---|---|---|---|---|
| | Pressure: 1 kg. per sq. cm. | | Pressure: 5 kg. per sq. cm. | | Pressure: 10 kg. per sq. cm. | |
| 100 | 639.4 | 0.5 | ... | ... | ... | ... |
| 150 | 663.5 | 1.0 | ... | ... | ... | ... |
| 200 | 687.0 | 1.5 | 682.5 | 1.5 | 676.0 | 1.5 |
| 250 | 711.0 | 2.0 | 707.5 | 2.0 | 703.0 | 2.0 |
| 300 | 735.0 | 2.0 | 732.5 | 2.0 | 729.5 | 2.0 |
| 350 | 759.0 | 2.0 | 757.0 | 2.0 | 755.0 | 2.0 |
| 400 | 783.5 | 2.0 | 781.5 | 2.0 | 780.0 | 2.0 |
| 450 | 808.0 | 2.0 | 807.0 | 2.0 | 805.5 | 2.0 |
| 500 | 833.0 | 2.0 | 832.0 | 2.0 | 831.0 | 2.0 |
| 550 | 858.0 | 2.0 | 857.5 | 2.0 | 857.0 | 2.0 |
| | Pressure: 25 kg. per sq. cm. | | Pressure: 50 kg. per sq. cm. | | Pressure: 100 kg. per sq. cm. | |
| 250 | 689.0 | 2.0 | ... | ... | ... | ... |
| 300 | 719.5 | 2.0 | 700.0 | 3.0 | ... | ... |
| 350 | 747.5 | 2.0 | 734.0 | 2.5 | 701.5 | 3.0 |
| 400 | 775.0 | 2.0 | 765.0 | 2.5 | 742.5 | 2.5 |
| 450 | 801.5 | 2.0 | 793.5 | 2.5 | 777.5 | 2.5 |
| 400 | 827.5 | 2.5 | 822.5 | 2.5 | 810.0 | 2.5 |
| 550 | 854.0 | 3.0 | 850.5 | 3.5 | 841.0 | 4.0 |
| | Pressure: 150 kg. per sq. cm. | | Pressure: 200 kg. per sq. cm. | | Pressure: 250 kg. per sq. cm. | |
| 350 | 648.5 | 4.0 | ... | ... | ... | ... |
| 400 | 715.0 | 2.5 | 676.0 | 2.5 | 623.0 | 4.0 |
| 450 | 759.0 | 2.5 | 737.0 | 3.0 | 710.9 | 5.0 |
| 500 | 796.5 | 2.5 | 782.0 | 4.0 | 765.0 | 5.0 |
| 550 | 830.5 | 4.0 | 820 | 6 | 807 | 10 |

## Erratum

In MECHANICAL ENGINEERING of February, 1931, page 149, the equation at the top of the first column should read:

$$k = 8.1 \times 10^{-4} \frac{\rho C^{0.4}}{Z^{0.12}} (\rho C M^{1/6})^{1.15}$$

instead of

$$k = 8.1 \times 10^{-4} \frac{\rho C^{0.4}}{Z^{0.12}} (C M^{1/6})^{1.15}$$

# Survey of Engineering Progress

## A Review of Attainment in Mechanical Engineering and Related Fields

### AERONAUTICS (See Internal-Combustion Engineering: The Deeble Duplex Engine)

### ENGINEERING MATERIALS

#### Fire-Resisting Cast Iron

THIS is part of a general article on the improvement of cast iron by alloying and superheating. The author believes that the ability of metal alloys to resist attack by furnace gases at high temperatures depends in the first place on the characteristics of the oxides of the alloyed metal. The rapid destruction of metal alloys which are not fire resistant is primarily due to the fact that the oxide formed on them falls off easily, with the result that new surfaces of the metal are exposed to the action of heat and gases. If, however, on the contrary, the oxides form a firmly adherent layer, the metal under them is protected against further destruction. Common iron oxide falls off very easily, and therefore ordinary irons and steels are not heat resistant. On the other hand, iron alloys containing aluminum and chromium are heat resistant. With proper contents of these metals the alloys form a thin surface layer of oxide which adheres very well. Aluminum alloys unfortunately are characterized by great porosity and brittleness, but chromium alloys are quite satisfactory for all practical purposes.

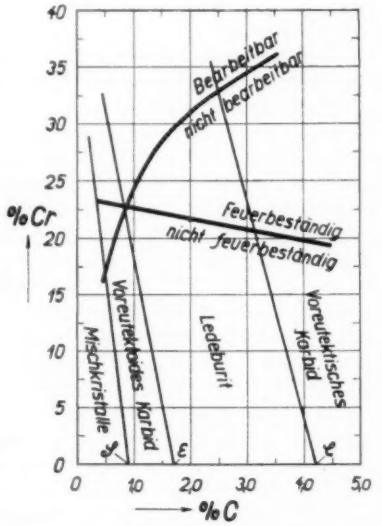


FIG. 1 CONSTITUTIONAL DIAGRAM OF IRON-CHROMIUM-CARBON ALLOYS INDICATING THEIR HEAT-RESISTING ABILITY AND MACHINABILITY

(*Bearbeitbar* = machinable; *Nicht Bearbeitbar* = not machinable; *Feuerbeständig* = fire resistant; *Nicht Feuerbeständig* = not fire resistant; *Voreutektisches Karbid* = preeutectic carbide; *Voreutektoides Karbid* = preeutectoid carbide; *Mischkristalle* = solid solution of crystals.)

The author investigated the heat-resisting ability and machinability of iron-chromium alloys containing up to 40 per cent chromium and up to 5 per cent carbon. He found that the oxidation at high temperatures in flue gases took place very differently from what it did in air. Thus, for example, an alloy containing 20 per cent chromium and 3 per cent carbon after 72 hr. of heating at 1000 deg. cent. (1832 deg. fahr.) showed scarcely any oxidation in air but crumbled up completely when heated for the same period of time and at the same temperature in furnace gases. Because of this difference of behavior he defines a fire-resisting alloy as one which, after being exposed three times for periods of 72 hr. each to furnace gases at a temperature of 1000 to 1050 deg. cent. (1832 to 1922 deg. fahr.), does not lose more than 0.5 per cent of its weight. This is not a scientific definition, but one of great convenience for practical purposes. Under this treatment a very clearly defined difference was found between fire-resisting and non-fire-resisting alloys. With low-carbon alloys the border line lies at about 23 per cent chromium. With an increase of carbon content the line falls to about 20 per cent chromium at 4 per cent carbon (see Fig. 1).

All the alloys below the heavy dividing line in Fig. 1 burn with remarkable speed, and therefore cannot be considered as fire-resisting alloys. Fig. 1 also indicates the approximate positions of points *S*, *E*, and *C* of the iron-carbon diagram as affected by increase in chromium content. The limit lines are straight but inclined, and all of them tend toward lower carbon contents with increasing chromium contents. Alloys intended for service where fire resistance is essential should not belong to the hypereutectic type. Thus it would appear from these curves that a fire-resisting cast iron with 22 per cent chromium should not contain more than 3 per cent carbon.

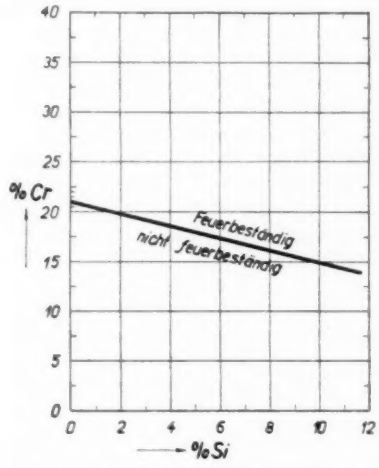


FIG. 2 HEAT-RESISTING PROPERTIES OF IRON-CHROMIUM-CARBON-SILICON ALLOYS HAVING A CONSTANT CARBON CONTENT OF 2.5 PER CENT

(*Feuerbeständig* = fire resistant; *Nicht Feuerbeständig* = not fire resistant.)

Although silicon in itself is not effective, it has been found that in combination with chromium a certain percentage of silicon does improve fire resistance. Fig. 2 shows that in alloys with a constant carbon content of 2.5 per cent the border line between fire-resisting and non-fire-resisting materials containing 22 per cent chromium may with an increase in silicon content be brought to the point where at 10 per cent silicon only 15 per cent chromium is required. The analysis, however, is not the only point in making fire-resisting cast iron that has to be considered. There are also certain difficulties in the way of porosity, tendency toward cracks, and rupture due to alternate heating and cooling. A cast iron which runs well and is highly heat resistant may contain, for example, 2 per cent carbon, 25 per cent chromium, and 0.75 per cent silicon. Unfortunately, however, after it has been used for a short time, particularly when heated and cooled, it develops cracks which make its ability to resist fire worthless.

It is not the analysis or the presence of impurities that produces all of this, but structural changes, primarily connected with changes of form. The author tried to overcome them by additions of silicon, as he states in the latter part of the article, and

claims that he has succeeded in doing so. The silicon runs up to 2 per cent. (Dr. of Engrg. Emil Schüz, of the Swabian Mills. Abstracted from *Mitteilungen aus den Forschungsanstalten*, vol. 1, no. 2, Nov., 1930, pp. 34–40, 4 figs., *pe*)

## FUELS AND FIRING

### The Reed-Lamie Process of Low-Temperature Carbonization

THIS process was developed for use with high-volatile coal and is now being carried out on a pilot plant in Detroit. One of the features is the effort to conserve the sensible heat content in the semi-coke and take advantage of the ease with which the hot semi-coke flashes into flame. In the process a gas-tight revolving retort is used and slack coal is fed into it. The interior of the retort is divided in a series of chambers, and within each of these chambers is placed a loose mass of impact bodies, some of which are spherical and some angular. The size, weight, and proportion of angular to spherical bodies are not the same in all chambers, but are selected according to the work which they are required to do. Their main functions are to transmit it to the distilling mass and to keep the walls of the retort free of carbon.

One of the products of the process is semi-coke in hot powdered form. It is remarkable for its mobility and will flow freely. Therefore there is no arching as with pulverized raw coal.

Of the by-products the tar shows a fairly high fraction, boiling within the gasoline range. This fraction consists almost entirely of aliphatic hydrocarbons and benzol, while cyclic hydrocarbons if present are in small amounts only. It is stated that this fraction when tested in a standard detonating engine shows a 100 per cent benzol equivalent and can thus be used as a blending material for the production of an anti-knock motor fuel. The next higher boiling fraction contains low-boiling phenols and a neutral oil, the phenol consisting largely of cresylic acid. The neutral oils can be used only as fuel oils, but the entire tar can be cracked to produce a motor fuel with high anti-knock characteristics. The semi-coke can be directly fired under a boiler. (*Power*, vol. 72, no. 24, Dec. 9, 1930, pp. 941–942, 2 figs., *r*)

### Experiences With Alcohol Fuel in Sweden

INTEREST in the use of alcohol fuel in Sweden dates back to about 1911 when considerable amounts of ethyl alcohol were manufactured as a by-product of the cellulose industry which was beginning to acquire a considerable importance in the country. It was realized at the time that the production of alcohol from this source might run as high as 50,000,000 liters (13,200,000 gal.) or more, an amount which could not be conveniently consumed in the form of beverages by a population of 6,000,000. The only industry that apparently could consume that amount would be motor-car transportation.

As a result of this a fairly intensive study of the burning of alcohol in motor-car engines was initiated in Sweden. At first the question under investigation was whether it would be possible completely to replace imported gasoline by native alcohol. In the course of time this problem has lost its primary importance, because the motor-car industry has developed today to such a point that even if all the alcohol were consumed as motor fuel, not more than about 20 per cent of its fuel requirements would be thus satisfied. Within the last few years the problem has therefore been whether it would be possible to replace straight gasoline or benzol by mixtures containing about 20 per cent of alcohol. Two factors of historical importance have contributed to make this problem more difficult.

During the war years, Sweden was completely cut off from foreign supplies of gasoline and benzene, and native alcohol was the only fuel that could be used in motor vehicles—and this fuel could not be properly purified because of lack of the necessary chemicals due to war restrictions on importations. The motor alcohol was therefore admixed with benzol from gas works, turpentine, acetone, wood alcohol, and other products. To make it still worse, good lubricants were as a rule not available, with the result that the operation of vehicles became difficult and the life of the engines short. This created an impression that alcohol as such is a bad fuel for motor vehicles. On top of this came a powerful wave of prohibition sentiment. Because of the fear that motor alcohol would be used for beverage purposes, its sale was completely prohibited for a time after the war. This, however, did not last long, and its sale was again permitted. The alcohol industry, however, had to begin its education of the public in the use of motor alcohol all over again.

The war restrictions on the use of fuels had some good results, however. During the war the distribution of motor alcohol was in the hands of a state commission which was able to collect sufficient statistical data to determine the number of users, and to some extent their experiences. This information showed that the majority of the engines designed for gasoline as a fuel were not properly adjusted for the use of the new fuel, which at that time consisted of 84 per cent alcohol and 16 per cent benzol or some other hydrocarbon. The preheating of the air was insufficient, the amount of fuel supplied too great, etc. It was estimated that probably not more than 10 per cent of the engines were properly adjusted for this fuel, and yet at most but 4 per cent of the engines were in any way hurt by the lack of this adjustment.

This is all the more impressive, as during the war period there was a shortage not only of fuel but of lubricating oil, and much of the latter was very poor.

The question of the best method of utilizing alcohol as a fuel is not an easy one. The idea of using high-compression engines to burn alcohol alone was discarded after a brief consideration, and the final decision was to employ from 75 to 80 per cent gasoline and the rest alcohol, with the proviso that the latter should be technically pure, i.e., practically free from water, as there was a fear that the presence of even very small amounts of water would cause separation of the mixture.

The importers of gasoline were at first very much opposed to the use of alcohol even as an admixture to their product, fearing that such admixture would be merely the thin end of a wedge to introduce alcohol as the base fuel. They soon found out, however, that there was no fear of the latter because of the limited volume of production of alcohol, and they also found that a mixture of about 75 per cent gasoline and 25 per cent alcohol makes an excellent fuel. As a matter of fact they now consider the gasoline-alcohol mixture as even better than straight gasoline. The only trouble is that the production of technical alcohol in Sweden is not developing as fast as might be desired, as the cellulose manufacturers have been slow in equipping their by-product alcohol plant with machinery for the production of technical alcohol.

One of the problems that had to be investigated was the possibility that alcohol-containing fuel might absorb water from the air, with the further danger that this would lead to separation of the two fuels. Tests have established, however, that the danger of absorption of water in this way is not an important one. Next an investigation of gasoline-alcohol-water mixtures was undertaken, and the results are presented in the original article in the form of a Gibbs diagram. From this it would appear that the content of water in the fuel must be very small as otherwise a breakdown mixture is apt to take place during cold winter weather. Another investigation showed that in the case of a heavy gasoline and high-grade alcohol (99.7 per cent) a mix-

ture of 70 per cent gasoline and 30 per cent alcohol would not contain more than 1 per cent of water at 20 deg. cent. (68 deg. fahr.) without the breaking down of the mixture. In winter at —20 deg. cent. (—4 deg. fahr.) the mixture would not contain more than 0.4 per cent without breaking down If, on the other hand, the mixture contains 80 per cent gasoline and 20 per cent alcohol, then the highest water content at +20 deg. cent. (68 deg. fahr.) can be only 0.6 per cent and at —20 deg. cent. (—4 deg. fahr.) only 0.25 per cent.

The Swedish investigation has established what mixtures are permissible for various types of gasoline and alcohol. The one trouble that has to be considered is that such very small amounts of moisture as have been indicated can very easily get into the fuel through leaks and improper handling.

The author points out, however, that in practice enormous amounts of alcohol-gasoline mixtures have been used and that no trouble from breakdown of the mixture has apparently been experienced. The next question which he takes up is the ability of the mixed fuels to generate power. He shows from this point of view that 25 per cent alcohol mixture behaves very well, in addition to which the alcohol acts as an anti-detonant. (Prof. E. Huberdick, Stockholm, in a paper before the Imperial Power Alcohol Co. in Germany; abstracted through *Petroleum Zeitschrift*, vol. 26, no. 50, Dec. 10, 1930, pp. 3–9, 4 figs., *g*)

## HYDRAULIC ENGINEERING

### Water Turbines of the Propeller Type

WHILE it is generally said that the speed type increases with reducing head, this statement must not be interpreted to mean that turbines in low-head plants operate in general at higher speeds than turbines in higher-head plants. The reverse is true. For the lower of two heads a "type" of turbine or a "specific speed" is employed which if used at the higher head would run at higher speed than the turbine adopted for the higher head; but in general under its own lower head it operates at lower speed. The speed for lower heads is therefore relatively higher. But an even far more radical step than the propeller-type turbine itself was the articulation of the propeller blades at the hub to permit change of blade angle under different conditions of operation. a thing impossible to attain with a Francis-type turbine.

It is only quite recently that ways have been developed to change the blade angle from the governor, for example, by oil pressure admitted through a hollow shaft. This is done in the Kaplan turbine. The progressive change of prevailing types of turbines for the past fifteen years, permitting a progressive increase in legitimate speed, has not always been made without sacrifice in operating results, particularly by way of reduction in the range of efficient operation under varying load; in other words, a reduction of average overall efficiency, as the author shows by curves. From this it would appear that with increasing speed the point of best efficiency approaches closer to full load, leaving less margin for absorbing sudden increases.

For competitive reasons, in addition to the development of types which can be legitimately operated at higher speed, there is also a tendency, resulting from keen competition, to almost universal overspeeding of turbines beyond the speed at which they should be operated, and the use of turbines of a higher speed type than best adapted to the given head. The customer must almost universally resist a pressure brought to bear by manufacturers for thus overspeeding, and the customer or his engineers must understand the analysis of turbine tests sufficiently to analyze the manufacturer's recommendation and to judge the speed at which it should operate for best average efficiency and longest life.

Curves in the original article are said to indicate that the high-speed propeller type of turbine, because of its sharp peak, is applicable in general only where the turbine can be run at or near the point of best efficiency, regardless of the load on the system. This possibility is favored by having a large number of units in a plant so that splitting up the load between them for any given load does not result in operation at low fractional position. Thus, for example, if there are only two units in a plant, when the load reaches slightly more than the capacity of one and the second unit has to be started, then both must operate at practically half-load until the load builds up higher. This operation at half-load would be very inefficient for the high-speed propeller turbines. On the other hand, if there were four units in a plant and the load slightly exceeded the capacity of two, requiring the third unit, the load per unit would be two-thirds of normal, with less reduction in efficiency; and with even more units, still better results are possible.

Another condition contributing toward justification of the fixed-blade high-speed propeller unit is a large storage so that the units can be run intermittently, either at best position or not at all, or preferably only on peak loads. This presupposes a power system so large that the units can be run for maximum output irrespective of system load conditions, allowing some other hydro or steam station to absorb the variations in load due to stopping and starting the propeller units. The possibility of so operating undoubtedly exists at times, although rarely, and it is expecting a very charitable attitude toward any one plant in a system to favor it in this way in order to permit it to justify itself. Where such operating conditions do exist, however, the fixed-blade propeller is quite satisfactory.

As a matter of fact the Kaplan curve establishes an entirely new type of efficiency curve in the field of hydraulic turbines. Although lower at normal load it is much higher at part-load positions. The question of selection of type of turbine is an economic and operating problem for each plant, individually. If a propeller costs $10 per hp., and a Kaplan $15, then this 50 per cent increased cost of turbine, or $5, will be only $2^1/_2$ per cent increase in cost of a completed development costing $200 per hp. In this case the average operating efficiency would need to be at least $2^1/_2$ per cent better to justify.

These favorable operating features of the Kaplan turbine after about five years of continuous trial of a considerable number of installations have practically standardized the Kaplan turbine as the low-head turbine in Europe. (L. F. Harza, Harza Engineering Co., in a paper before the Fifth Midwest Power Engineering Conference, Chicago, Ill., February 10 to 13, 1931. Abstracted from mimeographed preprint.)

## INTERNAL-COMBUSTION ENGINEERING (See also Motor-Car Engineering: British Bus With Marine-Type Heavy-Oil Engine)

### The Frichs Diesel Engine

TWO 800-i.hp. engines of this make have been installed on a large ferry recently built in Denmark. They are of the trunk-piston design with airless injection, and while rated at 800 i.hp. can develop this only on a continuous overload, the normal output being 700 i.hp. at 235 r.p.m. They have six cylinders of 370 mm. (14.5 in.) bore and 600 mm. (23.6 in.) stroke.

The crank chamber is formed of an upper and lower section flange-bolted together, and to this frame the cylinders are bolted. Inspection doors are fitted to the exhaust side of the upper crank chamber, and through these the pistons and connecting rods can be removed, if desired. There are four through bolts holding

each cylinder to the top of the crankcase, these extending to the main bearings. The pistons are oil-cooled and the covers and jackets are cooled by sea water.

The camshaft is at the level of the upper part of the frame and on the same side as the controls. It is driven by means of spur wheels, the whole gear and camshaft being enclosed and force-lubricated. The fuel pumps are arranged on the camshaft housing at the top and are direct driven from the camshaft, one pump being provided in front of each cylinder, Fig. 3.

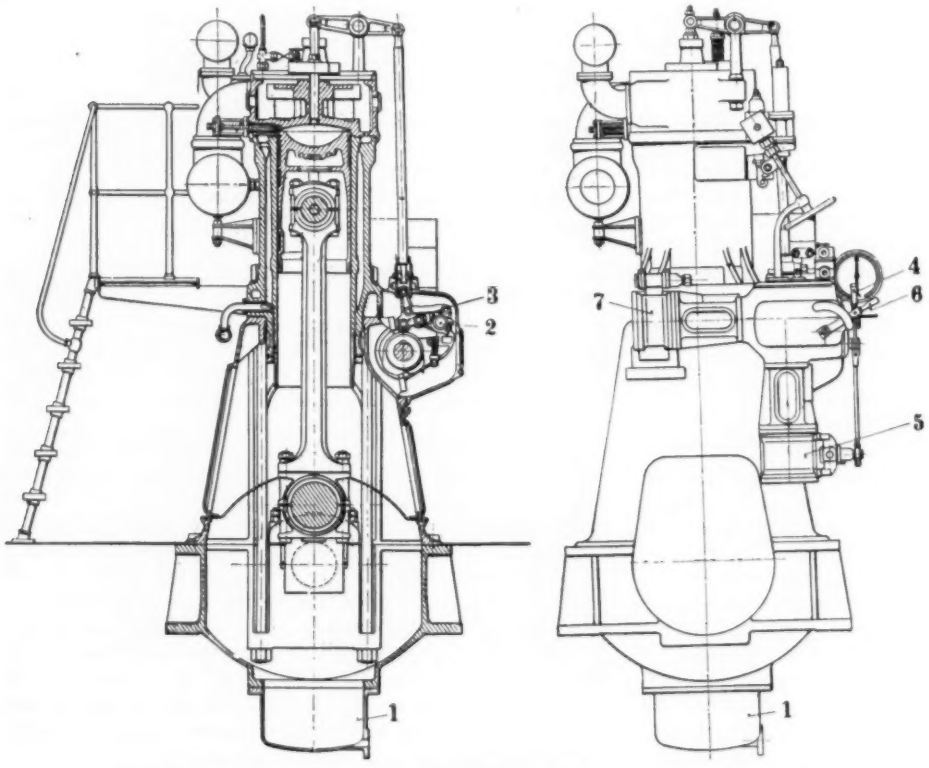


FIG. 3 END AND SECTIONAL ELEVATIONS OF THE FRICHS DIESEL ENGINE

On the camshaft is an ahead and astern cam for each of the suction, exhaust, and starting valves, as well as for actuating the pumps. The change from ahead to astern is effected by the hand lever (4), seen also in Fig. 3. The movement causes the short links (3) to be actuated, each of these being provided with two rollers, one for ahead and one for astern motion. The operation is effected through the intermediary of the maneuvering shaft (2) and the servo motor (5). Starting is controlled by the lever (6), seen at the extreme right, and this is also utilized for regulating the speed. The servo cylinder (7) comes into operation for starting purposes, and servo motors work under the oil pressure of the lubricating system. It is stated that this design of cam and valve gear gives an excellent degree of silence and that with it, wear is minimized.

When the trials of one of the engines were carried out with an output of 720 i.hp. at 235 r.p.m. the mean indicated pressure was 7.2 kg. per sq. cm., the mechanical efficiency 76.5 per cent, and the fuel consumption 142 gr. per i.hp-hr., or 0.315 lb. per i.hp-hr., which is equivalent to 0.41 lb. per b.hp-hr. At full load, with the engines indicating 810 hp. the mean indicated pressure was 7.8 kg. per sq. cm. and the mechanical efficiency 77 per cent. The fuel consumption was approximately equal to that when the power was 720 i.hp. (*British Motorship*, vol. 11, no. 132, Feb., 1931, p. 501, 3 figs., *d*)

### The Deeble Duplex Engine

THE main feature of this engine is its application of the double-acting principle. This is accomplished by employing a double piston or a piston within a piston, the inner one being stationary. This inner piston is made fast to the cylinder wall at the lower edge of its skirt. Both sides of the skirt are slotted to allow the wristpin of the moving piston to travel up and down. Just above the head of this fixed piston the cylinder is fitted with a valve chamber. As the moving piston makes the upward stroke gasoline vapor is drawn into the space beneath its head through an auxiliary bottom-end valve chamber located about midway in the cylinder between the head and crankcase.

This "under-side" gas charge is provided entrance to the combustion space beneath the traveling piston head via a wide gap in the piston skirt which is cut away for one-fourth of the total distance around the piston. A sectional piston ring closes this gap and prevents gas from blowing past the bulkhead into the crankcase. The ordinary piston rings on the movable piston prevent the gas from making its way to the upper combustion chamber.

One camshaft is provided for each set of valves, top side and auxiliary. The camshafts are set on opposite sides of the crankshaft, which is provided with seven main bearings. A gear pump provides pressure feed to all bearings, and is so designed that there are no outside oil lines.

A unique design feature is that one cam follower to each cylinder functions as an oil scavenging pump to assure circulation of oil, which finds its way to the crankcase side of the stationary pistons or bulkheads.

The first experimental engine was a twin-cylinder motorcycle engine remodeled. With an output of 25 hp. it has operated lineshafting and all the equipment of a machine shop for more than 500 hours. Tests are expected to be conducted shortly with a six-cylinder inverted in-line air-cooled engine calculated to deliver 300 hp. at 2000 r.p.m. The inverted type was selected because of advantages of small frontal area, increased visibility, and possibly greater durability. (Ned French in the *Aero Digest*, vol. 18, no. 1, Jan., 1931, p. 76, 3 fig., *d*)

## IRON AND STEEL ENGINEERING

### Rapid Open-Hearth Furnaces

IT IS CLAIMED that in these furnaces from five to six heats per day can be obtained. No details of the process are given. It is merely stated that two such furnaces were built at Kamaishi, Japan, the first completed in June, 1927, and the other in May, 1930. The charge varies from 15 to 20 tons of steel scrap, 15 to 20 tons of liquid pig, 5 to 15 tons of cold pig, 3 to 4 tons of lime, and 7 to 8 tons of iron ore. This is for a charge of 50 tons on a

furnace rated at 25 tons. It is claimed that because of the employment of the rapid principle the furnace can finish this double charge in much shorter time than would be required if this weight of metal were charged as two separate charges. The fuel consumption is between 45 and 50 kg. (100–110 lb.) of tar and 160 to 180 cu.m. (5650–6350 cu. ft.) of coke-oven gas per ton of ingots, equivalent to 330 lb. of coal of 12,600 B.t.u. per lb. per ton of steel. (Prof. N. E. Skaredoff in the *Iron and Coal Trades Review*, vol. 122, no. 3281, Jan. 16, 1931, p. 81, *g*)

## MACHINE TOOLS

### Tantalum Carbide Cutting-Tool Material

TANTALUM carbide with nickel as a matrix is being offered as a new hard cutting material under the trade name of "Ramet" by the Fansteel Products Co., North Chicago, Ill. From the moment tungsten carbide tools appeared on the market it was obvious that tantalum carbide would soon be employed for the same purpose as its hardness approaches that of tungsten carbide.

In its manufacture tantalum-bearing ore obtained from Australia is reduced and the metal is changed to the carbide form and then ground and thoroughly mixed with nickel. This mixture is then pressed to size and form in a hydraulic press. The material is next sintered in an electric furnace under controlled atmosphere. Untreated it cannot be brazed. It is therefore nickel plated and then heat treated in a controlled atmosphere, after which it can be brazed to a tool shank with copper or any of the other common brazing materials. The material will not withstand shock and strain as will tool steel, and the design of tool holder and method of mounting are therefore important. It is being successfully used for cutting bakelite, and readily cuts 10 to 15 per cent manganese-steel castings. A 3-in. soft steel bar can have a cut $^1/_2$ in. deep taken with a feed of 0.020 in. and at a speed of 170 ft. per min.

The physical properties of the tantalum carbide so far determined are: melting point, approximately 4100 deg. cent.; hardness, $89^1/_2$ to $90^1/_2$ on the C scale when using a Rockwell machine with a 60-kg. weight; and a computed ultimate tensile strength of between 250,000 and 300,000 lb. per sq. in.

A thermal conductivity less than one-third that of tungsten carbide is claimed. Tools made of this material keep cool, and tests are said to show that the work remains comparatively cool also. The low thermal conductivity is a safeguard against destruction of the brazed point, and in addition is an advantage in cutting hardened high-speed steel when using 10 to 15 deg. negative rake. (*The Iron Age*, vol. 127, no. 9, Feb. 26, 1931, p. 715, 2 figs., *d*)

## METALLOGRAPHY

### Microscopic Cracks in Heat-Treated Steels

THIS is part of a paper on the Art of Metallography presented at the February, 1931, meeting of the American Institute of Mining and Metallurgical Engineers by Francis F. Lucas, of the Bell Telephone Laboratories, New York City. Because of lack of space only a small portion of this important paper can be here abstracted, all the illustrations being omitted.

Dr. Lucas presented five figures illustrating martensitic structures in a specimen of plain carbon tool steel. These showed dark lines indicating very small quenching cracks which are confined to the needle areas. Generally speaking, the small cracks run across the needles, but some are seen which run along the edges of needles or lengthwise of the needles.

The cracks do not seem to occur in the fillings, and this would suggest that the mode of decomposition as indicated by the fillings has been somewhat different. If the cracks represent strains set up in quenching due to the rapidity with which volume changes occurred, then these cracks must indicate that transformation in the fillings has been at a slower rate and the metal has had time to adjust itself in these localities.

The significance and the control by heat treatment of the development of these very minute cracks seems to the author to be of great practical importance. If these are truly cracks and not lines of strain opened by the etching (and it is shown that they are cracks), then it means that those who are concerned with the production of hardened steel parts have something else to think about. If a hardened steel part containing these minute cracks is one which will be subjected to reversed cycles of stress, then each tiny crack becomes potentially the starting point for a fatigue failure.

Two very able investigators, Messrs. Davenport and Bain, have recently published a significant piece of research in which they show us how we may control the transformations in steel by a deferred or two-stage method of quenching. Volume changes have an opportunity to adjust themselves, and one might expect by the methods they describe to secure parts of great hardness, yet with freedom from these minute fissures and cracks. If so, it should be a boon to those who are concerned with the production of parts which must withstand reversed cycles of stress. Surely the methods will bear further study and application.

One of the author's associates at the Laboratories, Mr. J. R. Townsend, who for the past five years has devoted much time to fatigue studies, suggests that these very small cracks may fully account for the erratic behavior sometimes encountered in his tests of hardened steel specimens.

It seems possible that these cracks may be lines of strain opened by the etching reagent. Some work carried out a few years ago revealed that a fatigue crack which apparently ended when the specimen was lightly etched, actually extended beyond that apparent ending to a large inclusion toward which it was trending.

The identical specimen which revealed the presence of the minute quenching cracks was strain annealed for two hours at about 200 deg. cent. The surface was first carefully ground away to get well below any surface conditions developed by the previous etching. After annealing, the specimen was again prepared and etched, and the cracks developed.

Tempering at 200 deg. cent. had caused fine carbides to precipitate and the entire structure was now mottled. Contrast had been diminished and the specimen was difficult to photograph. The particle size of the carbide and the close proximity of the particles in general was responsible probably for failure of the lens to resolve fully the details.

It seems certain that the action of the etching reagent had caused the cracks to widen at the surface so that any measurements which might be made would be bound to err. The cracks develop by etching and only those which are relatively large can be seen in the unetched specimen. If we are to arrive at some reasonable approximation of their dimensions, we must make allowances for probable enlargement.

The measured widths of the small cracks are revealed by the photographs at 3500× ranges from about 0.01 in. to 0.04 in., and their length ranges upward from about 0.04 in. It is a simple matter to calculate the minimum dimensions. The width becomes $2.86 \times 10^{-6}$ in., and the length, $11.44 \times 10^{-6}$ in. (Francis F. Lucas, of the Bell Telephone Laboratories, New York City, in a paper presented at the annual meeting of the *American Institute of Mining and Metallurgical Engineers*, Feb., 1931, to be published by them later; abstracted from manuscript, *gA*)

## METALLURGY

### High-Temperature Metals for the Power Plant

THE paper starts with a general discussion of the subject, of which the matter of strength versus excess ductility is of particular interest.

The construction engineer used to demand 25 to 28 per cent elongation in a length of 2 in. in his bolts. Stresses put upon the pipe lines eventually became so great that with the 60,000-lb. per sq. in. tensile strength carbon-steel bolts then in use, there was not room enough in the bolt circle around the flanges which connected valves, fittings, and pipes to allow enough bolts to hold the pressure. Consequently the bolts used soon stretched. The manufacturer thereupon furnished bolts with 100,000 lb. per sq. in. minimum yield point and 125,000 lb. tensile strength, but only with their corresponding 16 per cent or 18 per cent elongation in 2 in. The idea was that if we put the yield point or beginning of first slight stretch high enough the yield point would not be reached; the bolt therefore could not stretch, and what, then, was the difference whether we had the 25 per cent stretch capacity or only 16 per cent stretch capacity? We had to make sure, of course, that the higher-strength steel was not enough harder to be brittle in any way. Use of such bolts now is standard practice practically everywhere for greater stresses, and engineers have come to see that extreme ductility has disabilities, and a stiffer bolt is preferable.

*Creep Characteristics of Cast Steel Versus Rolled or Forged Steel.* With reference to effect of grain size in the matter of creep, there is a sort of corollary. Since larger-grain-sized steel is more resistant to creep than steel of small grain size, and since working a metal in forging or rolling reduces the grain size, then castings, which of course are neither forged nor hot worked, should be more creep resistant than forged or rolled steel of the same composition. Our own tests reported two years ago show this to be a fact. Castings are stiffer than forgings at high temperatures and also at low temperatures. This may not be a matter only of grain size, but it also may be that disturbing the intergranular cement and the crystal arrangement by forging or rolling allows the crystals to move more easily thereafter, i.e., at lower stresses.

*Flow or Creep.* The author believes that there are two different and quite separate concepts, namely, the very slight flow or creep produced by low loads, and the much greater, faster elongation which occurs at stresses around and above the yield point.

As shown in figures obtained through careful tests in long-time testing equipment, a certain amount of flow is produced even with rather low loads, and in a general way the rate of flow is proportional to the amount of load. A rate of flow of 0.000001 in. per hour per inch of length of specimen is equivalent approximately to 0.01 in. per inch per year, or 1 per cent stretch. This can be, and we believe should be, considered largely as distortion. That is, should proper factors of safety be neglected and a tank, pipe, valve, or other apparatus be subjected continuously to high enough temperature, and sufficient pressure be built up to produce circumferential flow or stretch of 0.01 in. per inch per year, it would result simply in the slight expansion of the tank, pipe, or valve; and unless such increase of size interferes with operation or serviceability by making the apparatus take up too much room, throwing parts of the equipment out of line, etc., it would do little or no harm, certainly no harm so far as safety to life or plant is concerned. There is no danger of rupture for a long period of time unless for some reason flow is seriously localized through overheating at some point where it is not detected, as, for example, in a boiler or superheater tube.

Tests made by us, as well as those reported by others, show that test specimens of ductile metals at temperatures of more than 600 deg. fahr. (315 deg. cent.) and at stresses that produce flow, do not rupture until warning has been given through stretch or "flow" of 10 to 25 per cent. This is distinctly parallel to the test specimen in the short-time tension test which likewise elongates 10 to 25 per cent, both "necking down" before rupture. With this in mind, danger to life through failure by deformation from flow of such small magnitude that the total extension does not disturb serviceability over a period of years, may be dismissed as practically impossible, and the whole matter of useful life can be considered mainly from the standpoint of distortion per year or other suitable period, and whether such distortion is troublesome. (H. W. Spring, Crane Co., Chicago, Ill., in a paper before the Fifth Midwest Power Engineering Conference Chicago, Ill., February 10 to 13, 1931. Abstracted from mimeographed copy.)

## MOTOR-CAR ENGINEERING (See also Railroad Engineering: The Ro-Railer: Fuels and Firing: Experiences With Alcohol Fuel in Sweden)

### British Bus With Marine-Type Heavy-Oil Engine

THE Crossley Motor Co., of Manchester, England, has delivered to the City of Leeds a double-deck bus powered with a standard Gardner heavy-oil engine designed for marine service. The engine has six $4^1/_2 \times 6$-in. cylinders and a speed range under governor control of between 350 and 1350 r.p.m.

At one end of the engine is the fuel-pump assembly, which consists of two banks of three pumps, each operated by its own cam on a short camshaft with a lever by which it can be put into or out of action The fuel reaches the pumps through a combined heater and strainer and passes thence to the atomizers, which also have strainers in them.

The fuel pumps are of the constant-stroke type; injection commences at 10 deg. before top dead center, with a variable cut-off by means of a helical slot in a rotatable sleeve surrounding the pump plunger. The maximum period of injection is 20 deg.; the maximum fuel-injection pressure is about 2000 lb. per sq. in. Control of the amount of fuel injected per stroke is effected by the centrifugal governor, which takes effect upon the cut-off. The engine is therefore under governor control at all speeds; thus, when maneuvering, the driver need not use the accelerator pedal, for engaging the clutch increases the load and causes the governor to lengthen the injection period, so increasing the quantity of fuel supplied per stroke. Depressing the accelerator pedal increases the load on the governor spring, with the same result as governor action.

A special feature is that starting from cold is done by hand without the aid of artificial heating, by electric coils or otherwise. This is effected as follows: On each cylinder head is a lever normally pointing downward; when this is raised to a horizontal position the inlet valves are prevented from closing completely; thus all the cylinders are fully decompressed to permit the engine to be swung by hand. When the flywheel has gained momentum a lever beside the radiator is moved, causing the compression-control levers on the front two cylinders to be raised to a vertical position; this has the effect of temporarily increasing the compression in those two cylinders far above the normal and insures the firing of the charges therein, in spite of the engine's being cold. The remaining four compression levers are then raised to a vertical position, and when it is evident that all cylinders are firing the compression-control levers are successively lowered to their normal position. This position gives the inlet valves an opening point slightly in advance of top dead center and a closing point 40 deg. after bottom center. The

higher compression for starting is obtained by a timing of the inlet valves by which they close earlier, viz., at bottom dead center. In conjunction with this means of varying the compression for starting, provision is made whereby the governor control can be set to permit an increased fuel charge to be delivered to the sprayers.

A spring-loaded sprayer is fitted direct into the cylinder head so that its nozzle and three radial jet holes project directly into the main combustion chamber formed by the flat cylinder head and concave piston crown.

The normal compression ratio is 13 to 1 and the maximum m.e.p. is 98 lb. per sq. in. In its present form the engine weighs 25 lb. per b.hp. with flywheel, full water jackets, and lubricating oil. At 1300 r.p.m. it develops 75 b.hp. The chassis weighs 14,000 lb. and the unladen bus about 21,000 lb. (M. W. Bourdon in *Automotive Industries*, vol. 64, no. 7, Feb. 14, 1931, pp. 233–234, 3 figs., *d*)

## POWER-PLANT ENGINEERING (See also Welding: Arc Welding in the Power Plant: Metallurgy: High-Temperature Metals for the Power Plant)

### Dual-Purpose Power Plants and the Commercial Distribution of High-Pressure Steam

THE author points out that under present conditions the public utility in order to retain its electric-light and power business must be prepared to offer and deliver a complete service to meet the various demands of different users. For example, for the hotel and office building it must be ready to supply three commodities: steam for heating purpose, electric light, and power. For the larger manufacturer the public utility must be prepared to furnish not only large quantities of electric power but also steam, varying pressures and temperatures according to the demands of each particular manufacturer. Several recent power-station developments have been built of late to meet the various problems of this kind, such as the Deepwater station in New Jersey. Another interesting installation is that of the Southeastern Production Co. at Mobile, Ala., a power plant designed and built to furnish both power and steam to a new paper mill of the International Paper Co.

Another interesting installation is that of the Louisiana station of the Louisiana Steam Products, Inc., near Baton Rouge, La. This station has been constructed adjacent to the refinery of the Standard Oil Co. of Louisiana, and will supply hourly to the oil company approximately 840,000 lb. of steam of 135 lb. gage pressure and 438 deg. total temperature, and electrical power up to approximately 16,000 kw. maximum to the refinery. Steam will be generated at 640 lb. gage pressure, 750 deg. total temperature, in the boiler plant; this steam will pass through two or more of three 15,000-kw. steam turbines which will exhaust at the pressure and temperature of delivery to the refinery. Electric power generated in excess of that required by the refinery will be supplied to the Baton Rouge Electric Company, or to the transmission system of the Gulf States Utilities Company.

The exceptionally high load factor of this plant, estimated at about 80 per cent, justifies certain refinements, such as the use of both economizers and air preheaters in the boiler units. On the other hand, the fact that this is primarily an industrial plant has not warranted the expenditure for building structure that is usually considered desirable for a public-service plant of this size, and efforts are being made to obtain extreme simplicity in building and equipment without sacrificing economy or electric-generating capacity.

The main turbines will be simple, high-pressure, non-condensing machines. Low-pressure steam for three-stage feedwater heating will be obtained from the various steam-turbine-driven auxiliaries; the boiler-feed-pump turbines are to exhaust at about 5 lb. abs. to the low-pressure heater, and the fan turbines are to exhaust at about 5 lb. gage pressure to the deaerators. Steam for all auxiliaries and the high-pressure water is to be taken directly from the main-turbine exhaust lines. All other plant auxiliaries, except one fuel-oil pump, will be motor driven.

An unusually complete water-purifying plant, which will consist mainly of settling, clarifying, filtering, treating, and softening equipment, with a capacity of 2000 gal. per min. of treated Mississippi River water, is being provided to supply the large amount of boiler-feed make-up required.

The boiler plant is unique in that the fuel will be approximately 50 per cent natural gas, 33 per cent liquid refinery waste, and 17 per cent petroleum coke. The petroleum coke will be burned in pulverized form.

Another interesting combination station is that of the Western Electric Company at Point Breeze, Md., operating in combination with the Consolidated Gas, Electric Light, and Power Company of Baltimore, Md. This station does not generate any electrical power owing to the extremely varying steam demands, but is operated by the utility company under a five-year contract for the Western Electric Co., the utility company undertaking to furnish both steam and electrical energy without at the present time any production of by-product power.

Other plants of a similar kind mentioned in the original paper are those at Rochester and Cedar Rapids, Iowa. In the latter plant the original heating system when installed had as its source of supply in early days the exhaust from non-condensing steam engines. As the development in the central-station art progressed, this station was gradually rebuilt and equipped with condensing steam turbines and the engines were replaced with turbines and the central heating system supplied more and more by live steam through a reducing valve, until it was entirely of a live-steam basis.

In order to secure energy recovery from this steam at 225 lb. gage and 100 deg. superheat, a by-product turbine of the "reducing-valve" type has been installed and recently placed in service. This is a 7500-kw. non-condensing turbine taking its steam from the main head of the station at 225 lb. gage and 100 deg. of superheat. The turbine by means of a stage valve extracts steam at 100 lb. gage from the first stage for the heating of feedwater and for high-pressure-steam service. Steam passes through the other four stages of the turbine to the low-pressure heating system at varying pressures of from 5 to 25 lb. gage, depending on the steam demands and pressure requirements of the city. The turbine is capable of passing a maximum throttle flow of 250,000 lb. of steam per hour, with steam extraction up to 90,000 lb. per hr. from the first stage, and a flow to the low-pressure heating system of 160,000 lb. per hr. It is expected that this turbine will deliver to the station bus approximately 12,000 kw-hr. per year, and add a potential capacity under winter conditions of 7500 kw.

In considering such equipment for by-product power purposes it must be borne in mind that such a unit requires no other equipment that the unit itself—no condenser, no circulating water, and other associated auxiliaries that go with a condensing turbine. Such an installation has been actually made for about $25 to $40 per kw. The B.t.u. rate of the machine is approximately less than 4000 B.t.u. per kw-hr., energy recovered alone being considered, and the steam passed through the machine is available for central-station heating service and feedwater heating. (John M. Drabelle in a paper before the Fifth Midwest Power Engineering Conference, Chicago, Ill., February 10 to 13, 1931; abstracted from mimeographed preprint, *g*)

### A New British Unit Pulverizer

IT IS SAID that this pulverizer will be installed at the new Dunston B Power Plant of the Newcastle-on-Tyne Electric Supply Co., which is of interest as this station will be equipped with six water-tube boilers (625 lb. per sq. in. pressure and 825 deg. fahr. superheated-steam temperature), each of 156,000 lb. evaporation per hour. The pulverizer is known as the "Resolutor," and there has now been manufactured a pulverizer of this type of 10 tons per hour capacity.

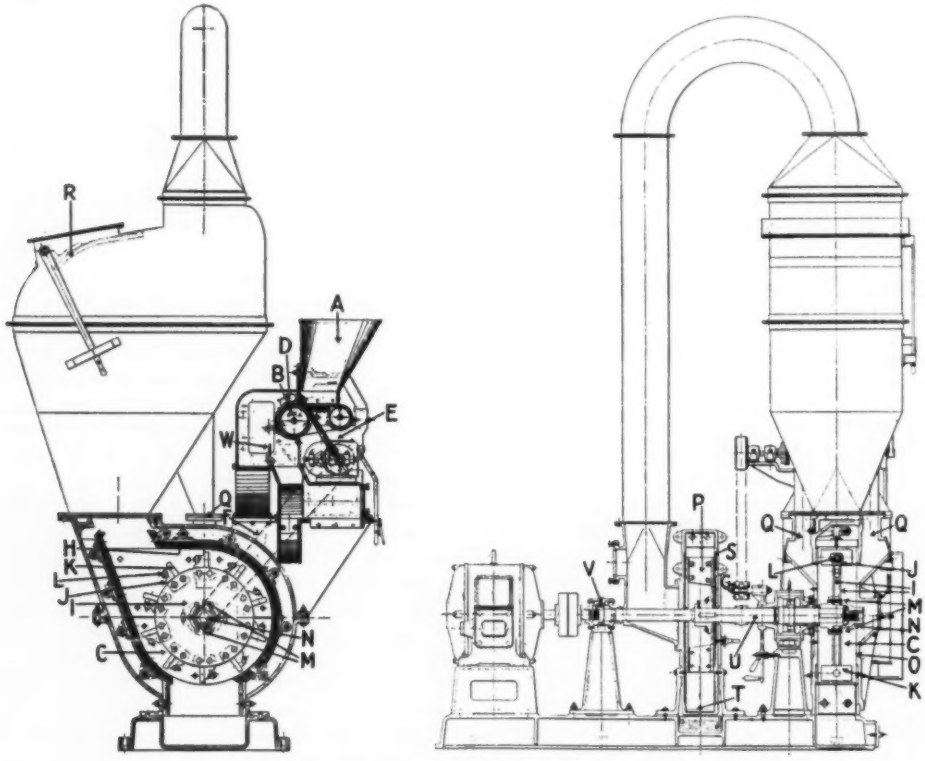


FIG. 4 THE "RESOLUTOR" UNIT PULVERIZER

Fig. 4 shows the arrangement of the various parts of these units. *A* represents the coal hopper, *B* the variable-speed belt-conveyor feeder, *C* the pulverizer chamber, *D* the variable-speed ratchet drive, *E* the crankarms, *F* the belt from main shaft to gearbox, *G* the jockey pulley, *H* the steel liner of the pulverizer chamber, *I* the runner-disk plates, *J* the brackets on runner disks, *K* the chrome-steel beaters, *L* the beater bolts, *M* the runner-disk driving pins, *N* the nuts for locking runner disk, *O* the pulverizer-chamber door, *P* the fan, *Q* the return arms, *R* the separator reflector to adjust degree of pulverizing, *S* the fan casing, *T* the fan-casing liner, *U* the main driving shaft, *V* the special ball-thrust bearing, and *W* the deflector.

This pulverizer is built by Clarke Chapman & Co., Ltd. Among other things, in their equipment slagging is prevented by using air which in the heated condition is passed through the coal in the pulverizer, about 25 per cent of the air for combustion traveling along with the coal to the burners. (*Mechanical World*, vol. 89, no. 2299, Jan. 23, 1931, pp. 78–79, 2 figs., *d*)

### Water Walls of the New Boiler Unit at Kips Bay Station, New York Steam Corporation

WITH the exception of the four corners, the entire wall surface on the furnace with bare metal consists of 4-in.-diameter No. 6 gage tubes spaced on $6^1/_8$-in. centers. The distance between faces of water-wall tubes front to back is 35 ft. 10 in. and the width 25 ft. 2 in. The furnace entrance to the boiler is formed by arch tubes connected on the lower end to the upper front-wall headers and the upper end to the lower boiler drum. These tubes are spaces on $6^1/_8$-in. centers. The water-cooled surface in the furnace bottom consists of a triple-depth hearth screen and a 36-in.-inside-diameter hammer-welded drum $1^1/_4$ in. thick and 46 ft. 6 in. long over the drum shell. With the exception of ten 4-in.-diameter downtakes to each of the front and rear lower water-wall headers, all the water obtained from the lower boiler drums is fed into this drum for circulation through the water walls.

The triple-depth hearth screen, which forms a water-cooled surface over the shallow ashpit, consists of rows of 4-in.-diameter tubes spaced on 21-in. centers. The vertical distance between the parallel rows of tubes is 12 in. The rows are so staggered that there is a horizontal offset of $10^1/_2$ in. between the intermediate rows. Where the tubes enter the 36-in.-diameter supply drum, offsets are provided in the tubes to give a maximum amount of clearance for the passage of ash into the hopper bottom.

The part of the boiler side wall comprising the surface exposed to radiant heat has been covered with water-cooled surface consisting of 4-in.-diameter No. 6 gage tubes spaced on $6^1/_8$-in. centers and similar to those installed on the furnace walls. The bottom ends of these tubes have been connected to an intermediate header, to which are also connected the upper ends of the center side-wall furnace tubes. The upper end of the boiler side-wall screen is connected to a distributing header. From this header, 4-in. riser tubes are carried to the upper half of the 60-in.-diameter boiler drums.

Details of the water-wall circulation and their insulation and casing are given in the original article.

Horizontal steel tie bands extending around the furnace are provided at the bottom, center, and top. Each pair of water-wall tubes is held to these bands by means of a tee welded to the tube and a cast-iron tee section bolted to the band. In addition to the above every sixth tube is held to the flanged casing by means of short lugs welded at intervals along the length of the tubes and bolted to the casing. All of the tees are so designed that tubes can be removed from the inside of the furnace without removing any of the steel casing panels which are bolted to the horizontal ties and corner buckstays. Provision is also made for the vertical expansion of the tubes and the linear expansion of the water-wall headers. All headers are covered with removable steel panels for access to handhole fittings. The four corners of the furnace above and below the tangential burners consist of refractory tile held to the corner buckstays by means of holding castings. The portions of the boiler side walls not water cooled consist of $13^1/_2$-in. firebrick, $2^1/_2$-in. insulating brick, and a flanged casing made of No. 10 B.W.G. steel plate. Rows of

holding tile attached to horizontal casing bars by means of castings are provided at intervals in this wall. (A. R. Ludt, Combustion Engineering Corp., New York, in *Combustion*, vol. 2, no. 7, Jan., 1931, pp. 30–37, *d*)

## RAILROAD ENGINEERING

### Engineering and Economics of Propeller-Driven Railway Cars

ONE of the advantages of propeller drive is that the rigid connection between the motor and the driving wheels is eliminated. Moreover, the high revolutions of the propeller permit its direct connection to the high-speed driving motor, which eliminates the conventional steam engine as practically the only convenient form of drive on railroads and permits the use of internal-combustion engines for driving units. Of course, the steam turbine is also adaptable to this purpose, as well as very high-speed reciprocating engines. Technically, electric drive is also suitable. Practically, however, electrification is applicable only on certain parts of the railroad system where distances are comparatively short and the density of travel is great.

The author considers next the matter of frictional resistance in the case of high-speed travel. He considers the propeller-driven car as the only means of obtaining land transportation at super-speeds. No other form of land transportation than that by rail can be used at such speeds, because of the imperfections of roads and danger to other users of the highways. With propeller-driven cars enormous speeds have been obtained. The Scotch engineer, George Bennie, obtained as high as 240 km. (149 miles) per hr., while Kruckenberg on the experimental stretch in Hanover attained a speed of 182 km. (113 miles) per hr. The author considers suspended railways, such as the Bennie, economically impractical because of the very high cost of construction. He does not consider, however, the possibility of using the upper deck as a motor-car roadway. The objections to the propeller drive are next considered. Among them, for example, are the possibility of the propeller's blowing out the flames of the kerosene lamps used for signaling, its noisiness, and finally the possibility that persons standing on a station platform might get entangled in the propeller. To show how unlikely it is that this last-mentioned accident would happen, the author shows a picture of a small girl unsuccessfully trying to get her hand into the propeller of a railroad train. As a more serious consideration is mentioned the question as to whether the present track permits the material increase in speed which alone would make the use of propeller-driven trains desirable. The author comes to the conclusion that any first-class track in good condition would permit speeds greater than those now employed, and that for several reasons it is safer to operate propeller-driven cars at higher speeds than ordinary trains.

The center of application of the drive of the propeller may be placed practically at the elevation of the inertia resistance of the train. The propeller itself may be used to advantage as a braking system. The lower weight of the train assures a reduced wear on the rails, notwithstanding the greater speed of travel. The gyroscopic action of the rapidly revolving propeller has a stabilizing effect, as has been practically proved by experiments carried out by the author himself.

Finally, it is possible to utilize the very considerable air pressure which develops at high speeds for stabilizing the vehicle on the rail. The author therefore comes to the conclusion that a speed of at least 150 km. (roughly 100 miles) can be safely obtained on ordinary railway tracks, and that it is merely a matter of time and further experiments before speeds up to 200 km. (125 miles) per hr. can be safely reached. It is important to get rid of the preconceived idea that lighter vehicles are more susceptible to derailment. Experiments made by Professor Prandtl would indicate that lighter vehicles are less apt to derail than heavy ones, because their inertia is smaller.

When it comes to speeds at which ordinary rail operation is no longer possible, propeller drive can be used with so-called "guided" operation in which the arrangement is such that the wheels are not permitted to leave the rails. Whether or not it is possible to employ this system on ordinary railroads is a matter on which sufficient data are not as yet available. It is believed, however, that this system can be applied on newly laid tracks without affecting the possibility of operating ordinary cars and locomotives on the same tracks, and furthermore without any material increase in cost.

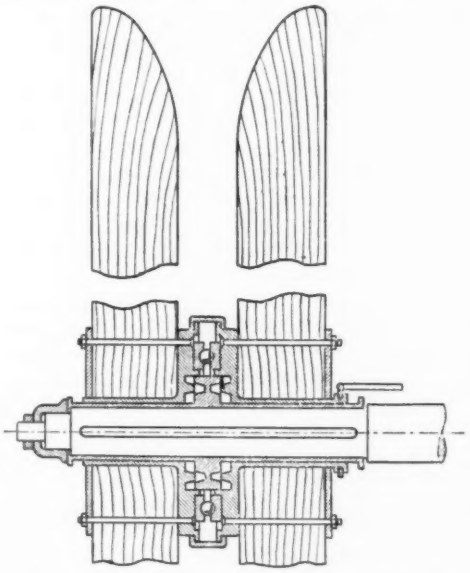

FIG. 5 DOUBLE PROPELLER WITH ALTERNATE COUPLING FOR REVERSING THE DIRECTION OF MOTION OF PROPELLER-DRIVEN RAILWAY CARS

Among the subjects taken up is that of reversing the direction of travel, which is of decided importance in railroad traffic. This can be done in a number of ways, the simplest one being to install air propellers at each end of the train which run in opposite directions. Kruckenberg replaces one propeller with another of opposite pitch. This has a number of disadvantages according to the author. Another solution is that recommended by the author in which the motor is alternately coupled with one of two propellers running in opposite directions. Such a set is shown in Fig. 5. Still another solution would be to employ an adjustable-pitch propeller. (Dr. of Engrg. Otto Steinitz in *Glasers Annalen*, vol. 108, no. 2/1286, Jan. 15, 1931, pp. 13–18, 5 figs., *g*)

### An Eight-Coupled Compound Locomotive

THIS locomotive has been recently constructed by Henschel & Son of Cassel for the Portuguese Beria Alta Railway, a connecting link in traffic between Lisbon and France via Spain. The locomotive is intended primarily for express passenger service and is slated to run at about 52 km. (32.3 miles) an hour average speed.

Compounding has been carried out on the DeGlehn principle, i.e., the cut-offs in the high- and low-pressure cylinders can be varied independently at will. At starting, or when otherwise desirable, live steam can be admitted to the large low-pressure cylinders, thereby temporarily increasing the tractive effort to a

considerable extent. Properly handled, this system makes a wonderfully "flexible" engine, giving great power at moderate or low speeds on gradients, with fast running when circumstances are favorable, and it is, no doubt, for this reason that compound engines of this type have for some years past found great favor both in Portugal and Spain, countries where the railways tend to be very irregular in profile.

In this locomotive the high-pressure cylinders are external and horizontal and have a diameter of 420 mm. (16.53 in.). These act upon the second pair of coupled wheels, and to obviate excessively long connecting rods the piston rods are suitably extended. The inside, low-pressure, cylinders drive the leading axle, and are therefore inclined somewhat steeply. Their diameter is 640 mm. (25.19 in.) and the stroke of 650 mm. (25.59 in.) is the same for both high-pressure and low-pressure pistons. Tail rods are fitted to both pairs of pistons, and the steam distribution is by long-travel, inside-admission piston valves worked by Walschaerts gear, of which four complete sets are provided, the inside links being actuated by eccentrics. This multiplicity of parts undoubtedly constitutes a drawback in the otherwise admirable DeGlehn system, especially when the general structure of the engine tends to inaccessibility. Inside eccentrics, in particular, are objectionable for many reasons, and although these may be avoided by the use of auxiliary outside return cranks and transfer shafts, as is done on many recent three-cylinder engines, the author thinks the system employed by Mr. Gresley, on the London and Northeastern Railway four-cylinder compound No. 10,000, offers the neatest method of providing independent valve control with a minimum of complication and interior motive organs. In the machine under notice, however, access is given to the mechanism with a freedom that is quite exceptional, all four links (the reversing armshafts, guide-bar brackets, and boiler support) being built up of castings and plate work in a remarkably neat manner. The reversing gear is on the right-hand side and is hand-operated.

The designer of this locomotive was materially assisted by the fact that the Portuguese main-line railways have a generous vertical loading gage, while the standard rail gage is 5 ft. 6 in. This makes it possible to provide a sufficiently deep and wide firebox by keeping the grate above the framing without resort to trailing carrying wheels [*The Locomotive* (London), vol. 37, no. 461, Jan. 15, 1931, pp. 1–2, 1 fig., *d*]

### The "Ro-Railer"

THIS is a new type of motor vehicle designed in England for use in both road and rail service. As now made it is a passenger vehicle and has a seating accommodation for 26 persons, but the same principle can be applied to freight transport.

In its general appearance the vehicle differs very little from an ordinary road vehicle, but the buffers and draw gear at both ends and the arrangement of the lamps, to enable the Ro-Railer to carry appropriate lights when driven on the rail in either direction, give it an individual note, while the flanged rail wheels are mounted on the axles on the inner sides of the road wheels. The pneumatic-tired road wheels are mounted on eccentrics fitted to outer extensions of the rail-wheel axles. When running on the road the road wheels are locked in a position concentric to the axle. When the vehicle is to be run upon rails it is driven to a place where the road has been made up level to the head of the rail. Then, with the rail wheels directly over the rails, it is driven forward for a few yards to a point where the made-up road is tapered off, so letting the rail wheels gradually come in contact with the rails and take the weight of the Ro-Railer off the road wheels, which are then raised clear of the rails, by half a turn of the eccentric mounting, and locked to the chassis frame by a pin. When running on the rails the road wheels do not revolve.

When it is desired to go from the rail to the road the operation just described is simply reversed. In the ordinary way the complete change-over should be carried out in less than five minutes; under test conditions the operation with a four-wheel Ro-Railer has been effected in two and a half minutes. The vehicle demonstrated was fitted with an engine developing a maximum horsepower of 120, and the transmission scheme includes a supplementary gearbox to give increased speed on long railway runs at low engine speed.

The vehicle has been designed purely for use on branch lines, especially those where the towns and villages lie some distance from the railway, but it can be also used for week-end traffic to the coast.

From the point of view of passenger traffic the advantages of the Ro-Railer are four in number: (1) Low running cost. Owing to the smaller tractive effort necessary, gasoline consumption will be reduced, while tire costs and other maintenance charges will be lessened. (2) Safer traveling While running at railway speeds the vehicle will be protected by the same system that has made British travel the safest in the world. On short tests speeds of 50 m.p.h. have been obtained, and that was not the limit by any means. (3) Comfort and improved visibility, when compared with the average branch-line train; comfort on road equal to similar type of vehicle. (4) Journeys shortened and the payment of heavy tolls avoided by railing the vehicle at convenient points. From the point of view of freight traffic there is, in addition to the advantages already mentioned, a further one: (5) Traffic can be actually from door to door without transferring the load at any point during transit.

The original article gives the principal data as to the vehicle. It is equipped with a six-cylinder engine developing from 65 to 110 hp., and the rate of gasoline consumption on the road is 8 miles per gallon (British) and on rails, 16 miles per gallon. The weight complete but without load is somewhat in excess of seven tons. (*The Railway Gazette*, vol. 54, no. 4, Jan. 23, 1931, pp. 123–124, 4 figs., *d*)

## REFRIGERATION

### Central-Station Refrigeration

BY CENTRAL-STATION refrigeration is meant the production of refrigeration in a central plant and its distribution to the users by pipes. A characteristic installation of this type, of which more will be said later, is the Merchants Refrigerating Company in Hudson Street, New York City, which supplies refrigeration not only to a market but also to a large building in the neighborhood owned by the Western Union Telegraph Company.

Contrasted to the power, lighting, and even heating central-station systems, the central-station refrigerating plant is but an infant. A great many steps must be taken before the ultimate system involving the proper mechanical and economic advantages is accomplished.

The author discusses the problem in question from an engineering point of view and covers such subjects as character of central plant, character of the pipe line, and the business and economic factors.

In the case of the Western Union Telegraph Company Building, refrigeration as stated above is supplied from the Merchants Refrigerating Company's plant within a short distance of the building, and covers such services as drinking water, manufacture of ice cream, ice making, restaurant refrigerators and serving boxes, and cooling water for the photographic room. The largest single item in refrigerating today is the cooling of drink-

ing water, as the maximum population of the building when completely occupied will be approximately 9000. One of the largest applications for central-station refrigeration is that of air conditioning for buildings, a very complex problem. Another type of service is household refrigeration in certain residential localities. This service will probably be confined to distribution in districts containing large groups of apartment dwellings. In some of the larger cities of the country there are groups ranging from 2000 to 4000 apartments within a few city blocks.

There is nothing new in the principle of such refrigeration equipment or service. It is, however, true that a thoroughly adequate and satisfactory layout for furnishing refrigeration to large groups of apartments from a central refrigerating plant has so far found but little application. This has probably been due to the fact that little, if any, effort has been directed toward this end. Any careful consideration of the engineering and economic advantages of such a layout can bring but one conclusion where many very large groups of apartments are located. It is believed that the initial cost of such a layout for a group of 2000 or more apartments would not exceed and probably be under the cost of individual refrigerators equal in capacity and refrigerating effect. Of course, the operating cost of the central-station arrangement would be considerably less due to the very much greater efficiency of the large unit as compared to the 2000 or more small units.

In the particular case of the Merchants Refrigerating Company the power plant is divided into two units: the main unit, which is equipped with five horizontal, double-acting, compound ammonia compressors aggregating 1600 tons of refrigeration; and the second power plant, which is really a breakdown plant and which contains three units of about 500 tons of refrigeration capacity. These two power plants are entirely separated so that the second plant provides emergency service in case of fire or complete breakdown in the main unit. The compressors are all direct-connected motor-driven machines, the motors of the synchronous type, 1960 volts, 2-phase, 60 cycles. The machines are operated with double intercooling. All the high-pressure liquid is cooled to the temperature corresponding to the intermediate pressure between stages. The latest compressor is equipped with a double inlet provided to take care of the two suction pressures employed in the station. The street pipe line operates at 10 to 12 lb. per sq. in. gage back pressure, and the freezers in the cold-storage warehouse operate on back pressure ranging from 2 to 4 lb. per sq. in. gage. Zero degrees fahrenheit calcium chloride brine is maintained at all times in the mains of the street pipe line. The largest of these mains are 12 in. and the maximum quantity of brine pumped from the station about 4000 gal. per min. One of the interesting features in connection with the power plant are the anhydrous ammonia meters. These furnish accurate information on the precise tons of refrigeration at all times. (Geo. A. Horne, Merchants Refrigerating Co., New York, N. Y., in a paper before the Fifth Midwest Power Engineering Conference, Chicago, Ill., February 10 to 13, 1931. Abstracted from mimeographed copy.)

## WELDING

### Arc Welding in the Power Plant

THE paper deals particularly with the experiences of the Detroit Edison Company. The selection of equipment, proper designing, and the other factors entering the problem depend in the final analysis on the man who deposits the weld. The Detroit Edison Company has been fortunate in being able to retain a nucleus of highly skilled welders. In work such as they do, a few of these expert mechanics, available for work requiring skilled attention, are the backbone of the organization. It is surely a mistake to use Bill Jones or Sam Brown on a job requiring much skill, when John Smith, an expert on that particular problem, is being used to weld two pieces of angle together. Know the ability of the man and keep him on work suited to that ability until he is competent to perform more skilfully, and many welding problems will cease to be problems. There is only one inspection for general welding, and that is inspection during the actual operation. A good foreman or supervisor need not spend much time watching an operator weld after he knows the individual's ability. Impress the qualified welder with the rigidity of your welding requirements and he will give uniformly good welds. Your foreman need but give his work a few minutes' inspection a day and successful welding will result. Couple these factors with laboratory checks, and good, efficient production is assured.

This is a brief outline of one test given to welders working for The Detroit Edison Company: The pieces composing the test specimen are as follows: Two pieces of standard 6-in. pipe 12 in. long with one end beveled at 45 deg. Two blank ends of 1-in. plate to fit in the 6-in. pipe ends. One $^3/_4$-in. pipe nipple $4^1/_2$ in. long. The pieces are assembled and tack welded on the floor and then placed in a rack about 5 ft. from the floor. All the welding is done in this fixed position. The number and size of beads, joining of bead ends, and the entire procedure are outlined to the welder before welding is started. On completion the piece is given an 800-lb. hydrostatic test and hammered with a $2^1/_2$-lb. hammer while under pressure. The number and location of leaks are noted and the specimen is taken away to be cut into standard tensile specimens. The coupons have the weld crown ground flush before being pulled. To pass this test for pipe welding the welder shall have no leaks, and the average of all tensile specimens shall be 45,000 lb. per sq. in., with no one specimen falling below 40,000 lb. per sq. in. No serious defects should be found in the weld. When the specimens have been tested the welder is shown the results, and any imperfections are pointed out to him and their causes explained. The results of the tensile tests instill a competitive rivalry and are productive of better welding. Peculiarities of arc control, temperature ranges, and crater control as shown by some welders are a source of information to the supervisor and laboratory technician. A regular series of tests carried out at stated intervals not only keep the welder alert, but prove a mine of information to the personnel working for better welding and justify a considerable outlay of time and money. As mentioned before, in the final analysis the operator will make or break an arc-welding program, and once this is recognized a long forward step is taken in the production of successful welds.

The hardest problem to be faced in building up a competent welding organization is the selection of skilled operators. Once this problem has been met and solved, most others will solve themselves. It is probably true that not enough time and money or study are spent on this all-important phase of arc welding. (William Zorn, Detroit Edison Co., Detroit, Mich., in a paper before the Fifth Midwest Power Engineering Conference, Chicago, Ill., February 10 to 13, 1931. Abstracted from mimeographed copy.)

## CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

# Revisions and Addenda to the Boiler Construction Code

IT IS THE policy of the Boiler Code Committee to receive and consider as promptly as possible any desired revision of the Rules and its Codes. Any suggestions for revisions or modifications that are approved by the Committee will be recommended for addenda to the Code, to be included later on in the proper place in the Code.

The Boiler Code Committee has received and acted upon a number of suggested revisions which have been approved for publication as addenda to the Code. These are published below, with the corresponding paragraph numbers to identify their locations in the various sections of the Code, and are submitted for criticisms and comment thereon from any one interested therein. Discussions should be mailed to the Secretary of the Boiler Code Committee, 29 West 39th St., New York, N. Y., in order that they may be presented to the Committee for consideration.

After 30 days have elapsed following this publication, which will afford full opportunity for such criticism and comment upon the revisions as approved by the Committee, it is the intention of the Committee to present the modified rules as finally agreed upon to the Council of the Society for approval as addenda to the Boiler Construction Code. Upon approval by the Council, the revisions will be published in the form of addenda data sheets, distinctly colored pink, and offered for general distribution to those interested, and included in the mailings to subscribers to the Boiler Code interpretation data sheets.

For the convenience of the reader in studying the revisions, all added matter appears in small capitals and all deleted matter in smaller type.

PREAMBLE—Insert the following:

The rules in Pars. P-193, P-260, P-261, and P-268, which bear on the reinforcement of openings, are under consideration for revision and as soon as a conclusion is reached they will be issued in amended form.

PAR. P-180. REVISE DEFINITION OF THE TERM *TS* UNDER THE FORMULA TO READ:

*TS* = ultimate tensile strength IN lb. per sq. in., stamped on THE shell plates OR SEAMLESS SHELLS as provided for in the MATERIAL specifications [for Steel Boiler Plate].

PAR. P-182. REVISED:

P-182. FOR LONGITUDINAL JOINTS the distance between the center lines of any two adjacent rows of rivets, or the "back pitch" measured at right angles to the direction of the joint, shall have the following minimum values:

*a* If $\frac{P}{d}$ is 4 or less, the minimum value shall be 2 *d*;

*b* If $\frac{P}{d}$ is over 4, the minimum value shall be:

$$2d + 0.1\ (P - 4d)$$

where

*P* = pitch of rivets in outer row where a rivet in the inner row comes midway between two rivets in the outer row, in.

*P* = pitch of rivets in the outer row less pitch of rivets in the inner row where two rivets in the inner row come between two rivets in the outer row, in. (It is here assumed that the joints are of the usual construction where the rivets are symmetrically spaced.)

*d* = diameter of the rivet holes in.

THE BACK PITCH OF CIRCUMFERENTIAL JOINTS MAY BE LESS THAN THAT CALLED FOR BY THE ABOVE FORMULAS PROVIDED THE LIGAMENTS BETWEEN RIVETS IN A CIRCUMFERENTIAL DIRECTION, AS WELL AS THOSE IN A DIAGONAL DIRECTION, AS DETERMINED BY THE RULES IN PAR. P-193 ARE SUFFICIENT TO WITHSTAND THE STRESS DUE TO PRESSURE, TOGETHER WITH ANY STRESS DUE TO WEIGHT COMPONENTS IN SUPPORT OF BOILER STRUCTURE, WITH A FACTOR OF SAFETY OF FIVE.

The back pitch of rivets shall be measured either on the flat plate before rolling, or on the median line after rolling, AND THE BACK PITCH AS THERE MEASURED SHALL GOVERN THE LOCATIONS OF RIVET HOLES IN THE BUTT STRAPS.

PAR. P-184. ADD THE FOLLOWING AS SECTON *e:*

*e* THE DISTANCE BETWEEN ANY TWO ROWS OF RIVETS IN A CIRCUMFERENTIAL JOINT OR "BACK PITCH" SHALL NOT BE LESS THAN 1.75*d*.

PAR. P-186. REVISE THIRD SENTENCE OF FIRST SECTION TO READ:

Joints between the doorhole flanges of furnace and exterior sheets may be butt or lapwelded by the fusion process, provided these sheets are stayed or otherwise supported around the doorhole opening and provided the distance from the flange to the surrounding [row of] stays or other supports does not exceed the permissible staybolt pitch as per Par. P-199.

REVISE THE SECOND SECTION TO READ:

Where the entire area is welded simultaneously, electric resistance butt welding OR BUTT WELDING WHERE THERMIT IS EMPLOYED AS THE HEATING ELEMENT WITHOUT THE INTRODUCTION OF EXTRANEOUS METAL may be used and the ultimate strength of the joint taken as 35,000 lb. per sq. in. as in the case of forge welding. EITHER METHOD [it] may, upon the request of a manufacturer who submits proper scientific data and evidence, be given a higher rating by the Boiler Code Committee than for forge welding, provided that an authorized inspector may demand a test of any one of the welded articles he may select for the purpose, and if, after witnessing such a test, he shall doubt the advisability of using the assigned rating for the weld, the case shall be referred to the Boiler Code Committee for its decision.

PARS. P-195 AND U-36. REVISE DEFINITION OF THE TERM *TS* IN THE FORMULA TO READ:

*TS* = tensile strength, lb. per sq. in., ORIGINALLY STAMPED ON THE PLATE USED IN FORMING THE HEAD

REVISE THIRD SECTION TO READ:

When a head dished TO A SEGMENT OF A SPHERE has a manhole or access opening that exceeds 6 in. in any dimension, the thickness shall be increased by not less than 15 per cent of the required thickness for a blank head computed by the above formula, but in no case less than $^1/_8$ in. additional thickness over a blank head. Where SUCH A dished head has a flanged opening supported by an attached flue, an increase in thickness over that for a blank head is not required. If more than one manhole is inserted in a head, the thickness of which is calculated by this

rule, the minimum distance between the openings shall be not less than one-fourth of the outside diameter of the head.

INSERT THE FOLLOWING AS THE SIXTH SECTION:

NO HEAD SHALL BE OF A LESSER THICKNESS THAN THAT REQUIRED FOR A SEAMLESS SHELL OF THE SAME DIAMETER.

REVISE PRESENT SIXTH SECTION TO READ:

A blank head of a semi-elliptical form in which half the minor axis or the depth of the head is at least equal to one-quarter of the inside diameter of the head shall be made at least as thick as the required thickness of a seamless shell of the same diameter. If a flanged-in manhole which meets the Code requirements is placed in an elliptical head, the thickness OF THE HEAD shall be the same as for a head dished TO A SEGMENT OF A SPHERE with a dish radius equal to 0.8 the diameter of the shell and with the added thickness for the manhole.

PARS. P-197 AND U-38, AND P-198 AND U-39. COMBINE AS SECTIONS *a* AND *b* OF PARS. P-197 AND U-38:

PARS. P-197*a* AND U-38*a*. REVISED:

*a* The corner radius of an unstayed dished head measured on the concave side of the head shall not be less than 3 times the thickness of the material in the head; but in no case less than 6 per cent of the diameter of the shell. IN NO CASE SHALL THE THINNING DOWN AT THE CORNER RADIUS OF THE KNUCKLE OF ANY DISHED HEAD DUE TO THE PROCESS OF FORMING EXCEED 10 PER CENT OF THE THICKNESS REQUIRED BY THE FORMULA IN PAR. P-195.

PARS. P-198 AND U-39. INSERT THE FOLLOWING NEW PARAGRAPH:

FLAT HEADS

THE THICKNESS REQUIRED IN UNSTAYED FLAT HEADS, WHICH ARE UNPIERCED AND ARE RIGIDLY FIXED AND SUPPORTED AT THEIR BOUNDING EDGES BY RIVETED OR BOLTED ATTACHMENTS TO SHELLS OR SIDE PLATES, SHALL BE CALCULATED BY THE FOLLOWING FORMULA:

$$t = a\sqrt{\frac{0.162\,P}{S}}$$

WHERE

$t$ = THICKNESS OF PLATE IN HEAD, IN.

$a$ = DIAMETER, OR SHORT SIDE OF AREA, MEASURED TO THE CENTER OF THE INSIDE ROW OF RIVETS OR BOLTS, IN.

$P$ = MAXIMUM ALLOWABLE WORKING PRESSURE, LB. PER SQ. IN.

$S$ = ALLOWABLE UNIT WORKING STRESS, LB. PER SQ IN. = $\frac{TS}{5}$

$TS$ = ULTIMATE TENSILE STRENGTH STAMPED ON THE PLATES, AS PROVIDED FOR IN THE SPECIFICATIONS FOR STEEL BOILER PLATE, LB. PER SQ. IN.

PAR. P-230*b*. IN THE THIRD LINE OF THE FINE-TYPE MATTER FOLLOWING THE FORMULA, REPLACE "*p*" BY "$D_1$", AND REVISE DEFINITION OF $D_1$ TO READ:

$D_1$ = longitudinal SPACING [pitch] of crown bar WHICH SHALL NOT EXCEED TWICE THE MAXIMUM ALLOWABLE STAYBOLT PITCH, in.

PAR. P-253. REVISED:

P-253. *Rivet and Staybolt Holes.* All holes in braces, lugs and sheets for rivets or staybolts shall be drilled [full size with plates, butt straps and heads bolted up in position], or they may be [drilled or] punched AT LEAST $^1/_8$ IN. LESS THAN FULL DIAMETER FOR MATERIAL NOT MORE THAN $^5/_{16}$ IN. THICK AND AT LEAST $^1/_4$ IN. LESS THAN FULL DIAMETER FOR MATERIAL MORE THAN $^5/_{16}$ IN. THICK [not to exceed $^1/_4$ in. less than full size for plates over $^5/_{16}$ in. in thickness and $^1/_8$ in. less than full size for plates not exceeding $^5/_{16}$ in. in thickness and then drilled or reamed to full size with plates, butt straps and heads bolted up in position].

Such holes shall not be punched in material more than $^5/_8$ in. thick.

FOR FINISHING THE RIVET HOLES, THE PLATES, BUTT STRAPS, BRACES, HEADS AND LUGS SHALL BE FIRMLY BOLTED IN POSITION BY TACK BOLTS FOR FINAL DRILLING OR REAMING TO FULL DIAMETER.

The finished holes must be true, clean and concentric.

PAR. P-257. ADD THE FOLLOWING PARGRAPH AS SECTION *b*:

*b* FUSION WELDING MAY BE USED TO SEAL THE CALKING EDGES OF CIRCUMFERENTIAL-RIVETED LAP JOINTS OF POWER BOILERS PROVIDED THE PLATES DO NOT EXCEED 0.30 PER CENT CARBON AND THAT THEIR THICKNESS IS AT LEAST $^1/_8$ IN. MORE THAN THAT REQUIRED FOR A SEAMLESS SHELL OF THE SAME DIAMETER, SAME WORKING PRESSURE AND SAME GRADE OF MATERIAL. FOR FIRE-TUBE BOILERS THE THICKNESS OF THE PLATES AT THE CALKING EDGES OF CIRCUMFERENTIAL SEAMS IF TO BE SEAL WELDED SHALL BE AT LEAST $^1/_8$ IN. MORE THAN 60 PER CENT OF THAT REQUIRED FOR A SEAMLESS SHELL OF THE SAME DIAMETER, SAME WORKING PRESSURE, AND SAME GRADE OF MATERIAL. SUCH SEAL WELDING SHALL NOT BE APPLIED UNTIL AFTER THE BOILER IS MADE TIGHT AS EVIDENCED BY THE REGULAR HYDROSTATIC PRESSURE TEST PRESCRIBED IN PAR. P-329. SEAL WELDING MAY BE USED ON NOZZLES AND THEIR REINFORCING PLATES UNDER THE SAME CONDITIONS. ON UNSTAYED DISHED HEADS, SEAL WELDING SHALL NOT BE APPLIED CLOSER THAN $^1/_2$ IN. TO THE POINT OF TANGENCY OF THE KNUCKLE OF THE FLANGE. SEAL WELDING MAY BE APPLIED ONLY WHEN THE WELD METAL IS DEPOSITED IN A SINGLE LAYER HAVING A THROAT THICKNESS OF NOT LESS THAN $^3/_{16}$ IN., NOR MORE THAN $^5/_{16}$ IN. THE HEAT FROM WELDING SHALL NOT DISTORT THE PLATE OR LOOSEN THE RIVETS IN SUCH A MANNER AS TO BREAK THE INITIAL BOND EFFECTED IN THE RIVETED JOINT. AFTER SEAL WELDING, THE VESSEL SHALL BE RESUBJECTED TO THE PRESCRIBED HYDROSTATIC TEST.

PAR. P-261*b*. ADD FOLLOWING SENTENCE:

THE REQUIRED STRENGTH OF THE RIVETS IN SHEAR IN THE FLANGE OF A NOZZLE MAY BE COMPUTED BY BOTH SECTIONS *a* AND *b*, AND THE LESSER OF THE TWO VALUES USED.

PAR. P-261. ADD THE FOLLOWING NEW SECTION:

*c* IN CASE A SHELL IS MADE THICKER THAN REQUIRED BY THE CODE IN ORDER TO ALLOW FOR CORROSION OR FOR ANY OTHER REASON, THE RULES IN THIS PARAGRAPH SHALL BE BASED ON THE REQUIRED THICKNESS OF THE SHELL.

PAR. P-269. REVISE FIRST SENTENCE TO READ:

P-269. *Safety-Valve Requirements.* Each boiler having more than [either] 500 sq. ft. of water-heating surface, or in which the generating capacity exceeds 2000 lb. per hour, shall have two or more safety valves.

PAR. P-274. REVISE SECOND SECTION TO READ:

The heating surface shall be computed for that side of the boiler surface exposed to the products of combustion, exclusive of the superheating surface. In computing the heating surface for this purpose, only the tubes, fireboxes, shells, tube sheets and the projected area of headers need be considered, EXCEPT THAT FOR VERTICAL FIRE-TUBE BOILERS, ONLY THAT PORTION OF THE TUBE SURFACE UP TO THE MIDDLE GAGE COCK IS TO BE COMPUTED. The minimum number and size of safety valves required shall be determined on the basis of the aggregate relieving capacity and

the relieving capacity marked on the valves by the manufacturer. Where the operating conditions are changed, or additional heating surface such as water screens or water walls is connected to the boiler circulation, the safety-valve capacity shall be increased, if necessary, to meet the new conditions and be in accordance with Par. P-270. The additional valves required on account of changed conditions may be installed on the steam line between the boiler and the main stop valve except when the boiler is equipped with a superheater or other piece of apparatus, in which case they may be installed on the steam pipes between the boiler drum and the inlet TO THE SUPERHEATER OR [of the] other apparatus, provided that the steam main between the boiler and points where a safety valve or valves may be attached has a cross-sectional area at least 3 times the combined areas of the inlet connections to the safety valves applied to it.

PAR. P-291. REVISED:

P-291. *Water Glasses and Gage Cocks.* Each boiler shall have at least one water-gage glass, with connections not less than 1/2 in. pipe size. [The lowest visible part of the water glass shall be not less than 2 in. above the lowest permissible water level.] The water-gage glass shall be equipped with a valved drain.

THE LOWEST VISIBLE PART OF THE WATER GAGE GLASS SHALL BE AT LEAST 2 IN. ABOVE the lowest permissible water level, WHICH LEVEL shall be that at which there will be no danger of overheating any part of the boiler when IN OPERATION [it is operated with the water not lower than] AT that level. THE [This] LOWEST PERMISSIBLE WATER LEVEL for the usual types of boilers is given in Par. A-21 of the Appendix.

BOILERS OF THE HORIZONTAL FIRE-TUBE TYPE SHALL BE SO SET THAT WHEN THE WATER IS AT THE LOWEST READING IN THE WATER-GAGE GLASS THERE SHALL BE AT LEAST 3 IN. OF WATER OVER THE HIGHEST POINT OF THE TUBES, FLUES, OR CROWN SHEET.

PAR. P-296. REVISE FIRST PART TO READ:

P-296. *Steam Gages.* Each boiler shall have a steam gage connected to the steam space or to the water column or its steam connection. The steam gage shall be connected to a siphon or equivalent device of sufficient capacity to keep the gage tube filled with water and so arranged that the gage cannot be shut off from the boiler except by a cock placed near the gage and provided with a tee or lever handle arranged to be parallel to the pipe in which it is located when the cock is open; FOR BOILERS CARRYING 500 LB. PRESSURE OR OVER, VALVES MAY BE USED IN PLACE OF COCKS.

PAR. P-301. REVISED:

P-301. *Stop Valves.* Each steam-discharge outlet, except safety-valve and superheater connections, shall be fitted with a stop valve located at an accessible point in the steam delivery line and as near to the boiler nozzle as convenient and practicable. When such outlets are over 2-in. pipe size, the valve or valves used on the connection shall be of the outside-screw-and-yoke rising-spindle type SO AS TO INDICATE BY THE POSITION OF ITS SPINDLE WHETHER IT IS CLOSED OR OPEN, and the wheel may be carried either on the yoke or attached to the spindle.

PAR. P-308. REVISED:

P-308. Each boiler shall have a bottom blow-off pipe, fitted with a valve or cock, in direct connection with the lowest water space practicable; the minimum size of pipe and fittings shall be 1 in., and the maximum size shall be 2 1/2 in., except that for boilers 24 in. or less in diameter the minimum size of pipe and fittings may be 3/4 in. Straight-run globe valves of the ordinary type as shown in Fig. P-19, or valves of such type OR SO INSTALLED that dams or pockets can exist for the collection of sediment IN SUFFICIENT QUANTITIES TO OBSTRUCT THE FLOW, shall not be used on such connections. Return connections of the same size or larger than the size herein specified may be used, and the blow-off may be connected to them. In such case, the blow-off must be so located that the connection may be completely drained.

PAR. P-314. ADD THE FOLLOWING:

IN VERTICAL TUBULAR BOILERS, FEEDWATER SHALL BE INTRODUCED AT A POINT NOT LESS THAN ONE-FOURTH THE LENGTH OF THE TUBE ABOVE THE LOWER TUBE SHEET OR CROWN SHEET. IN VERTICAL BOILERS OF THE TUBELESS, STUB OR PORCUPINE TYPE, A DEFLECTION PLATE SHALL BE ATTACHED TO THE INNER SIDE OF THE OUTER SHELL DIRECTLY IN FRONT OF THE POINT OF INTRODUCTION OF FEEDWATER. THIS LATTER METHOD OF INTRODUCTION OF THE FEED MAY BE USED ON ALL TYPES OF VERTICAL BOILERS, IF SO DESIRED.

PAR. P-318. REVISE LAST SENTENCE TO READ:

On boilers having more than 100 sq. ft. of heating surface, the feed pipe shall be not less than 3/4 in. pipe size, BUT IN NO CASE SHALL THE FEED PIPE BE LESS THAN 1/2 IN. PIPE SIZE.

PAR. P-328. REVISE FIRST SENTENCE OF SECOND SECTION TO READ:

These latches or fastenings shall be of the automatic positive-locking type having a latch or bolt in a fixed bracket on the DOOR, door frame or furnace front.

PAR. P-332. REVISE FIRST SECTION TO READ:

P-332. Each boiler shall conform in every detail to these Rules, and shall be distinctly stamped with the symbol as shown in Fig. P-21, WHICH STAMPING IS A GUARANTEE BY THE MANUFACTURER THAT HE HAS COMPLIED WITH ALL THE REQUIREMENTS OF THE CODE [denoting that the boiler was constructed in accordance therewith.]

Section II—Revisions have been proposed in the following specifications which are either identical with or based on the specifications of the American Society for Testing Materials:

Carbon-Steel and Alloy-Steel Forgings (Spec. S-10)—A.S.T.M. Spec. A 18-30

Malleable Castings (Spec. S-15)—A.S.T.M. Spec. A 47-30

Boiler Rivet, Staybolt, and Extra-Refined Bar Iron (Spec. S-16)—A.S.T.M. Spec. A 84-30

Lap-Welded and Seamless Steel and Lap-Welded Iron Boiler Tubes (Spec. S-17)—A.S.T.M. Spec. A 83-30

Welded and Seamless Steel Pipe (Spec. S-18)—A.S.T.M. Spec. A 53-30

Welded Wrought-Iron Pipe (Spec. S-19)—A.S.T.M. Spec. A 72-30

The following new specifications have been added to Section II, and will be designated as Spec. S-25:

Open-Hearth Iron Plate of Flange Quality—A.S.T.M. Spec. A 129-30T

For detail schedule concerning the above specifications communicate with Secretary of the Boiler Code Committee.

PAR. H-5. REVISED:

H-5. Specifications are given in [Pars. S-1 to S-263 of] Section II of the Code for the important materials used in the construction of boilers. Material for parts of low-pressure heating boilers [required to resist internal pressure] for which specifications have been provided, shall conform to those specifications except as otherwise specified herein.

PARS. H-40 AND H-93. REVISED:

WHEN A STOP VALVE IS USED IN THE SUPPLY PIPE CONNECTION OF A SINGLE BOILER, THERE SHALL BE ONE USED IN THE RETURN PIPE CONNECTION. IT IS RECOMMENDED THAT NO STOP VALVES

BE PLACED IN THE SUPPLY AND RETURN PIPE CONNECTIONS OF A SINGLE BOILER INSTALLATION.

A STOP VALVE SHALL BE USED IN EACH SUPPLY AND RETURN PIPE CONNECTION OF TWO OR MORE BOILERS CONNECTED TO A COMMON SYSTEM.

IT IS RECOMMENDED THAT THE RETURN PIPE CONNECTION OF

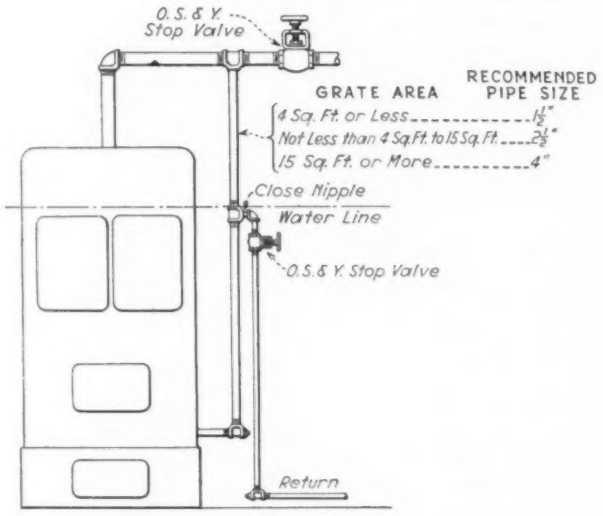
O.S. & Y. Stop Valve
GRATE AREA
RECOMMENDED PIPE SIZE
4 Sq. Ft. or Less ---- 1½"
Not Less than 4 Sq. Ft. to 15 Sq. Ft. ---- 2½"
15 Sq. Ft. or More ---- 4"
Close Nipple
Water Line
O.S. & Y. Stop Valve
Return

FIG. H-3

EACH BOILER SHALL BE SO ARRANGED AS TO FORM A LOOP SUBSTANTIALLY AS SHOWN IN FIG. H-3 SO THAT THE WATER IN EACH BOILER CANNOT BE FORCED OUT BELOW THE SAFE WATER LEVEL.

PROVISION SHALL BE MADE FOR CLEANING THE INTERIOR OF THE RETURN PIPING AT OR CLOSE TO THE BOILER.

WHEN STOP VALVES OVER 2 IN. IN SIZE ARE USED THEY SHALL BE OF THE OUTSIDE-SCREW-AND-YOKE TYPE.

WHEN STOP VALVES ARE USED THEY SHALL BE PROPERLY DESIGNATED SUBSTANTIALLY AS INDICATED BELOW BY TAGS OF METAL OR OTHER DURABLE MATERIAL FASTENED TO THEM.

SUPPLY VALVE—NUMBER ( )
DO NOT CLOSE WITHOUT ALSO CLOSING
RETURN VALVE—NUMBER ( )

RETURN VALVE—NUMBER ( )
DO NOT CLOSE WITHOUT ALSO CLOSING
SUPPLY VALVE—NUMBER ( )

[If valves are used in the supply and return mains they shall be locked and sealed open and bear tags stating that provision must be made to prevent pressure from building up in the boiler whenever the valves are closed. It is recommended that no valves be placed in the supply and return mains of single boiler installations.]

PARS. H-44 AND H-97. REVISED:

*Water-Relief Valves.* AT LEAST ONE water-relief valve shall be connected to EACH [all] hot-water HEATING OR HOT-WATER SUPPLY boilers. The valve shall be of the diaphragm-operating type, without guide wings below the seat, set to open at or below the maximum allowable working pressure. No water-relief valve shall be smaller than ½ in. nor LARGER [greater] than 2 in. standard pipe size. [The outlets of water-relief valves shall have open discharges in plain sight.] THE VALVE SHALL BE PLACED ON A VERTICAL DEAD END PIPE ATTACHED TO THE COLD-WATER SUPPLY PIPE CONNECTION CLOSE TO THE BOILER OR DIRECTLY TO THE BOILER WITHOUT AN INTERVENING VALVE. THE VERTICAL DEAD END PIPE TO WHICH THE VALVE IS ATTACHED SHALL BE AT LEAST 1 IN. NOMINAL PIPE SIZE, AND THE VERTICAL DISTANCE FROM THE COLD-WATER SUPPLY PIPE OR FROM THE BOILER CONNECTION TO THE WATER-RELIEF VALVE SHALL BE AT LEAST 6 IN.

PARS. H-61 AND H-114. REVISED:

*Water-Gage Glasses.* Each steam boiler shall have [at least] one OR MORE water-gage glasses, WITH THE LOWER FITTING PROVIDED WITH A VALVE OR PET COCK TO FACILITATE CLEANING.

PARS. H-63 AND H-116. REVISE FOURTH SENTENCE OF PAR. H-63 AND THIRD SENTENCE OF PAR. H-116 TO READ:

No connections, except for combustion regulator, drain[s] or steam gage[s], shall be ATTACHED TO [placed on] the PIPING [pipes] connecting a water column to a boiler.

REVISE FIFTH SENTENCE OF PAR. H-63 AND FOURTH SENTENCE OF PAR. H-116 TO READ:

If the water column or gage glass is connected to the boiler by pipe and fittings, A cross[es or], tee[s], OR EQUIVALENT, IN WHICH A DRAIN VALVE AND PIPING MAY BE ATTACHED, shall be PLACED IN [used on] the water PIPING connection AT EVERY RIGHT-ANGLE TURN to facilitate cleaning.

PAR. H-64 REVISED:

H-64. *Low-Water Fuel-Supply Cut-Off.* *a* IT IS RECOMMENDED THAT ON ALL AUTOMATICALLY FIRED STEAM OR VAPOR-SYSTEM BOILERS, A LOW-WATER FUEL-SUPPLY CUT-OFF BE INSTALLED IN SUCH LOCATION THAT IT AUTOMATICALLY CUTS OFF THE FUEL SUPPLY WHEN THE SURFACE OF THE WATER FALLS TO THE LOWEST SAFE WATER LINE.

*Fusible Plugs.* *b* A fusible plug, if used, shall be placed at the lowest safe water line and in contact with the products of combustion.

PAR. H-74. REVISED:

H-74. *Material for Base Metal.* The base metal composing the plates of [autogenously] FUSION-welded heating boilers shall be of weldable flange or firebox quality conforming to the requirements of Pars. H-122 to H-136, inclusive, OR OF SPECIFICATIONS S-1 OR S-25 OF SECTION II OF THE CODE. IF DESIRED, STEEL OF LOWER TENSILE STRENGTH THAN SPECIFIED MAY BE USED, THE DESIRED TENSILE LIMITS TO BE SPECIFIED WITH A RANGE OF 10,000 LB. PER SQ. IN.

PAR. H-117. REVISED:

H-117. *Low-Water Fuel-Supply Cut-Off.* *a* IT IS RECOMMENDED THAT ON ALL AUTOMATICALLY FIRED STEAM OR VAPOR-SYSTEM BOILERS, A LOW-WATER FUEL-SUPPLY CUT-OFF BE INSTALLED IN SUCH LOCATION THAT IT AUTOMATICALLY CUTS OFF THE FUEL SUPPLY WHEN THE SURFACE OF THE WATER FALLS TO THE LOWEST SAFE WATER LINE.

*Fusible Plugs.* *b* A fusible plug, if used, shall be placed at an accessible point in the combustion chamber.

PAR. M-2. ADD THE FOLLOWING SECTION:

IF, IN THE DEVELOPMENT OF THE ART OF WELDING, OTHER MATERIALS THAN THOSE HEREIN DESCRIBED BECOME AVAILABLE, SPECIFICATIONS MAY BE SUBMITTED FOR CONSIDERATION.

PAR. M-3*a*. REVISED:

M-3*a*. Steel plate SUBJECT TO PRESSURE IN [when used for] any part of a miniature boiler of riveted construction [where

under pressure] shall be of the firebox or flange grades. [but] FOR RIVETED SHELLS THE PLATES SHALL [in no case] NOT BE [shall steel of] less than 1/4 in. IN thickness AND FOR SEAMLESS [be used for riveted] shells SHALL BE NOT [or] less than 3/16 in. IN thickness [for seamless shells]. [The] Heads [if] used as tube sheets with tubes rolled in, shall be at least 8/16 in. thick.

PAR. M-4. ADD SECTIONS *b* AND *c* TO READ:

*b* MINIATURE BOILERS MAY BE FABRICATED BY MEANS OF FUSION WELDING PROVIDED THE MATERIALS USED CONFORM TO SPECIFICATIONS S-1 FOR STEEL BOILER PLATE, OR S-2 FOR STEEL PLATES OF FLANGE QUALITY FOR FORGE WELDING OF SECTION II OF THE CODE, OR TO THE REQUIREMENTS FOR PIPE MATERIAL SPECIFIED IN PAR. M-2.

BEFORE BEING PERMITTED TO WORK ON THE FABRICATION OF ANY MINIATURE BOILER UNDER THESE RULES, EACH WELDER IS REQUIRED TO QUALIFY UNDER THE QUALIFICATION TESTS FOR WELDERS IN THE CODE FOR UNFIRED PRESSURE VESSELS. THE INSPECTOR MAY AT ANY TIME CALL FOR THE QUALIFICATION TEST OF ANY OF THE WELDERS ENGAGED IN THE FABRICATION OF MINIATURE BOILERS.

*Maximum Allowable Working Stress.* *c* WHEN CONSTRUCTED IN ACCORDANCE WITH THESE RULES, THE MAXIMUM ALLOWABLE WORKING STRESS OF A WELDED JOINT, AT RIGHT ANGLES TO THE DIRECTION OF THE JOINT, SHALL BE THAT SPECIFIED IN THE CODE FOR UNFIRED PRESSURE VESSELS FOR THE GRADE OF FUSION WELDING USED.

PAR. M-7. REVISED:

M-7. Circumferential riveted joints, where used, shall conform to the requirements in Par. P-184 of Section I of the Code. [Autogenous welding may be used for joints in miniature boilers where the strain is carried by other construction which conforms to the requirements of the Code and where the safety of the structure is not dependent upon the strength of the weld.]

PAR. M-11. REVISED:

M-11. Every miniature boiler shall be fitted with not less than three brass washout plugs of 1 in. iron-pipe size, which shall be screwed into openings in the shell near the bottom. [reinforced to give four full threads]. IN A MINIATURE BOILER OF THE CLOSED-SYSTEM TYPE WHICH IS HEATED BY REMOVABLE INTERNAL ELECTRIC HEATING ELEMENTS AND WHERE THE OPENINGS FOR THE HEATING ELEMENTS MAY BE USED FOR CLEANING PURPOSES, SUCH OPENINGS MAY BE USED FOR WASHOUT OPENINGS. All threaded openings in the boiler [shell] shall be provided with a riveted or welded reinforcement if necessary, to give four full threads therein.

PAR. M-19. RENUMBER AS PAR. M-20 AND INSERT NEW PAR. M-19 TO READ:

M-19. *Hydrostatic and Hammer Tests for Welded Construction.* EACH BOILER OF WHOLLY OR PARTLY WELDED CONSTRUCTION SHALL BE SUBJECTED TO A HYDROSTATIC PRESSURE EQUAL TO 3 TIMES THE MAXIMUM ALLOWABLE WORKING PRESSURE, AND WHILE SUBJECT TO THIS HYDROSTATIC PRESSURE SHALL BE GIVEN A THOROUGH HAMMER OR IMPACT TEST. THIS IMPACT TEST SHALL CONSIST OF STRIKING THE SHEET SHARP BLOWS 2 TO 3 IN. APART ALONG BOTH SIDES OF THE WELDED SEAM WITH A LONG-HANDLED HAMMER. THE BLOWS SHALL BE AS RAPID AS A MAN CAN CONVENIENTLY STRIKE A SHARP, SWINGING BLOW, AND AS HARD AS CAN BE STRUCK WITHOUT BENDING THE SHEET. THE WEIGHT OF THE HAMMER SHALL BE EQUAL TO 10 PER CENT OF THE WEIGHT OF 1 SQ. FT. OF THE WALL OF THE VESSEL, BUT NOT LESS THAN 1 LB.

PAR. I-19. REVISE FIRST SECTION TO READ:

I-19. *Tube-Hole Tolerance and Use of Ferrules.* The INITIAL diameter of finished tube holes shall not exceed the nominal diameter of the tubes by an amount greater than shown in the following table:

PAR. I-21. REVISED:

I-21. *General Flanging.* The inspector shall see that in flanged sections there are no cracks due to the flanging operation, no deep hammer marks, burned sections, scars, or other injurious surface defects. It is to be noted that reduction in thickness is not below the designed thickness at the heel of the flange, and that the flanged section is practically true to form as designed. [When flanged manholes are used the corners shall be well rounded to a radius not less than that specified in the Code.] The manhole flange and reinforcing ring shall, when used, be installed in accordance with the requirements of the Code.

PAR. U-1. REVISED:

U-1. The Rules in this Section apply to CLOSED Unfired Pressure Vessels [over 6 in. in diameter, having a volume of more than 1.5 cu. ft. and] carrying a pressure of over 15 [30] lb. per sq. in., constructed of material herein specified.

PAR. U-12. REVISED:

U-12. ALL MATERIALS for the important PARTS [materials] used in the construction of [boilers and] UNFIRED pressure vessels, FOR WHICH specifications are given in [Specifications S-1 to S-24 of] Section II of the Code [and when such materials are used for the construction of unfired pressure vessels they] shall conform [there] TO SUCH REQUIREMENTS.

PAR. U-17. REVISE THE TABLE IN THIS PARAGRAPH BY STRIKING OUT THE WORDS "TO 72 IN." IN THE NEXT TO THE LAST ITEM, AND BY STRIKING OUT THE WORDS "OVER 72 IN., 1/2 IN." IN THE LAST ITEM.

PAR. U-23. MODIFY REVISION AS PUBLISHED IN DECEMBER, 1930, ISSUE TO READ:

U-23. Pressure vessels may be fabricated by means of fusion welding under the rules given in Pars. ———, provided the CONSTRUCTION [fabrication] is in accordance with the REQUIREMENTS FOR MATERIAL AND DESIGN AS REQUIRED BY THIS CODE AND THE FUSION WELDING PROCESS USED CONFORMS TO THE SPECIFICATIONS FOR THE GRADE OF WELDING INDICATED FOR EACH CLASS OF VESSEL [Recommended Procedure for Fusion Welding of Pressure Vessels given in the Appendix, as follows:

*a* Air vessels, when the inside diameter does not exceed 60 in., or the working pressure does not exceed 200 lb. per sq. in., or the temperature does not exceed 250 deg. fahr.

*b* Vessels, in which the circumferential joints only may be welded, when the inside diameter does not exceed 48 in., or 72 in., when at least 75 per cent of the load on a flat head is supported by tubes or through stays extending from head to head.

All joints in vessels covered by this Code and of any dimensions may be fusion welded provided that in addition to meeting the requirements for material and design, they will conform to specifications now being prepared for inclusion in this Code, based on those which have been published under the heading, Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers.]

PAR. U-27. ADD THE FOLLOWING SECTIONS:

THE BACK PITCH OF CIRCUMFERENTIAL JOINTS MAY BE LESS THAN THAT CALLED FOR BY THE ABOVE FORMULAS PROVIDED THE LIGAMENTS BETWEEN RIVETS IN A CIRCUMFERENTIAL DIRECTION, AS WELL AS THOSE IN A DIAGONAL DIRECTION AS DETERMINED BY THE RULES IN PAR. U-59, ARE SUFFICIENT TO WITHSTAND THE STRESS DUE TO PRESSURE, TOGETHER WITH ANY STRESS DUE TO

WEIGHT COMPONENTS IN SUPPORT OF THE BOILER STRUCTURE, WITH A FACTOR OF SAFETY OF FIVE.

THE BACK PITCH OF RIVETS SHALL BE MEASURED EITHER ON THE FLAT PLATE BEFORE ROLLING, OR ON THE MEDIAN LINE AFTER ROLLING, AND THE BACK PITCH AS THERE MEASURED SHALL GOVERN THE LOCATIONS OF RIVET HOLES IN THE BUTT STRAPS.

PAR. U-30. REVISED:

U-30. The riveted longitudinal joints of a shell which exceeds $^1/_2$ IN. IN THICKNESS [48 in. in diameter], shall be of butt-and-double-strap construction. This rule does not apply to the portion of a shell which is staybolted to an inner sheet.

PAR. U-31. REVISE FIRST SECTION TO READ:

U-31. The longitudinal joints of a shell not more than $^1/_2$ IN. IN THICKNESS [48 in. in diameter], with the exception given below, may be of lap-riveted construction; but the maximum allowable working pressure of such construction shall not exceed [nor] 200 lb. per sq. in. for vessels less than 24 in. in diameter, NOR 150 lb. per sq. in. FOR VESSELS 24 IN. IN DIAMETER OR OVER.

ADD THE FOLLOWING SECTION AT END OF PARAGRAPH:

THE SPHERICAL PORTION OF VESSELS OF ANY DIAMETER WHICH ARE WHOLLY SPHERICAL OR PARTLY HEMISPHERICAL, MAY BE CONSTRUCTED WITH LAP JOINTS PROVIDED THAT IF THE PLATE THICKNESS EXCEEDS $^3/_8$ IN., THE SEVERAL SPHERICAL SECTIONS OF PLATE SHALL BE HOT PRESSED TO THE PROPER RADIUS OF CURVATURE. WHEN THE VESSEL CANNOT BE COMPLETED IN THE SHOP, THE WHOLE STRUCTURE SHALL BE CAREFULLY AND COMPLETELY FITTED UP READY FOR RIVETING BEFORE SHIPMENT.

PAR. U-52. ADD THE FOLLOWING AS SECTION *b*:

*b* FUSION WELDING MAY BE USED TO SEAL THE CALKING EDGES OF RIVETED JOINTS AND RIVET HEADS OF UNFIRED PRESSURE VESSELS, PROVIDED THE PLATES DO NOT EXCEED 0.30 PER CENT CARBON AND THAT THE THICKNESS OF THE PLATE OR HEAD AFFECTED BY THE WELDING IS AT LEAST $^1/_8$ IN. MORE THAN THAT REQUIRED FOR A SEAMLESS SHELL OF THE SAME DIAMETER, THE SAME WORKING PRESSURE AND THE SAME GRADE OF MATERIAL. SUCH SEAL WELDING SHALL NOT BE APPLIED UNTIL AFTER THE VESSEL IS MADE TIGHT AS EVIDENCED BY THE REGULAR HYDROSTATIC PRESSURE TEST PRESCRIBED IN PAR. U-64. SEAL WELDING MAY BE USED ON NOZZLES AND THEIR REINFORCING PLATES UNDER THE SAME CONDITIONS. ON UNSTAYED DISHED HEADS, SEAL WELDING SHALL NOT BE APPLIED CLOSER THAN $^1/_2$ IN. TO THE POINT OF TANGENCY OF THE KNUCKLE OF THE FLANGE. SEAL WELDING MAY BE APPLIED ONLY WHEN THE WELD METAL IS DEPOSITED IN A SINGLE LAYER HAVING A THROAT THICKNESS OF NOT LESS THAN $^3/_{16}$ IN. NOR MORE THAN $^5/_{16}$ IN. THE HEAT FROM WELDING SHALL NOT DISTORT THE PLATE OR LOOSEN THE RIVETS IN SUCH A MANNER AS TO BREAK THE INITIAL BOND EFFECTED IN THE RIVETED JOINT. AFTER SEAL WELDING, THE VESSEL SHALL BE RESUBJECTED TO THE PRESCRIBED HYDROSTATIC TEST.

PAR. U-53. REVISE FIRST SECTION TO READ:

U-53. All vessels for use with compressed air, OR SUBJECT TO INTERNAL CORROSION, 18 in. in diameter or over, and not exceeding 36 in. in diameter, shall have a handhole in the shell or head, or a manhole or at least two plugged threaded openings of not less than 2 in. pipe size. When two threaded openings are used, they should be located in the heads or in the shell near the heads.

PAR. U-54. REVISED:

U-54. [ALL] Vessels for use with compressed air, OR SUBJECT TO INTERNAL CORROSION, over 36 in. in diameter, shall have a manhole, excepting those whose shape or use make it impracticable, IN WHICH CASE THEY SHALL HAVE A 4- BY 6-IN. HANDHOLE, OR ITS EQUIVALENT IN AREA, LOCATED AS NEAR EACH HEAD AS PRACTICABLE. An elliptical manhole opening shall be not less than 11 by 15 in., or 10 by 16 in. in size. A circular manhole opening shall be not less than 15 in. in diameter.

PAR. U-56. REVISED:

[U-56. Manhole frames in shells shall have the proper curvature and, when the diameter exceeds 48 in., shall be riveted to the shell with two rows of rivets.]

PAR. U-64. REVISED:

U-64. *Hydrostatic Test.* Each vessel constructed under these rules shall be tested under hydrostatic pressure to NOT LESS THAN [50 lb. in excess of the maximum allowable working pressure when same does not exceed 100 lb. and to] $1^1/_2$ times the maximum allowable working pressure [above 100 lb.], except that FOR enameled vessels THE TEST PRESSURE NEED NOT EXCEED [shall not be tested in excess of] the working pressure. FOR VESSELS OF FUSION-WELDED CONSTRUCTION THE REQUIREMENTS OF PAR. U-0 SHALL APPLY.

PAR. U-75. REVISE THIRD SECTION TO READ:

When the heads are thicker than the shell, THE WELDING EDGES [they] shall be reduced in thickness BY MACHINING, CHIPPING OR GRINDING APPROXIMATELY as shown in Fig[s]. U-7[A or U-7B], TO WITHIN 20 PER CENT OF THE THICKNESS OF THE SHELL.

PAR. U-91. REVISED:

U-91. *Material.* Steel plates for the shells of brazed vessels shall be made by the open-hearth process and THE THICKNESS shall not exceed $^3/_8$ in. [in thickness] EXCEPT WITH THE VARIATION PERMITTED BY PAR. 12 OF SPECIFICATIONS S-1 PLUS 0.01 IN. WHEN THE LONGITUDINAL SEAM IS OF THE LAP-JOINT TYPE, NOR 1 IN. PLUS 0.02 IN. WHEN THE LONGITUDINAL SEAM IS OF THE DOUBLE-STRAP BUTT-JOINT TYPE. Plates $^1/_4$ in. thick or heavier shall be of either flange or firebox quality as provided for in the Specifications for Steel Boiler Plate [as given in Pars. S-5 to S-17] of Section II of the Code. Sheets lighter than $^1/_4$ in. shall have the properties as provided for in [the] Specifications S-13 [for Steel Plate for Brazing as given in Pars. S-280 to S-285].

PAR. U-95. REVISED:

U-95. A longitudinal [seams] LAP JOINT shall have the edges of the plate lapped a distance of not less than 8 times the thickness of the SHELL PLATE [metal]. FOR DOUBLE-STRAP BUTT-JOINT CONSTRUCTION, THE TOTAL AMOUNT OF LAP OF THE INNER AND OUTER STRAPS SHALL BE EQUAL TO AT LEAST 16 TIMES THE THICKNESS OF THE SHELL PLATE, ONE-HALF OF WHICH SHALL BE ON EACH SIDE OF THE ABUTTING EDGES. THE WIDTH OF THESE STRAPS SHALL NOT DIFFER MORE THAN 25 PER CENT OF THE WIDTH OF THE WIDER ONE. The laps shall be held closely in position substantially metal to metal, by stitch riveting or other sufficient means. The brazing shall be done by placing the flux and brazing material on one side of the joint and applying heat until this material comes entirely through the lap and shows uniformly along the seam on the other side. Sufficient flux must be used to cause the brazing material to so appear promptly after reaching the brazing temperature. The brazing material used shall be such as to give a joint which has a shearing strength of at least 10,000 lb. per sq. in.

PAR. U-96. REVISED:

U-96. *Head* AND GIRTH JOINTS. [Seams.] Heads shall be driven into the shells with a tight driving fit, and shall be thoroughly brazed in approximately the same manner as the longitudinal seam for a depth or distance from the end of the shell equal to at least 4 times the thickness of the shell metal. WHEN

A VESSEL IS FABRICATED WITH MORE THAN ONE COURSE IN THE SHELL, THE GIRTH JOINT MAY BE OF EITHER THE LAP OR BUTT TYPE. IF OF THE LATTER TYPE, THE CIRCUMFERENCE OF THE ABUTTING COURSES SHALL NOT DIFFER BY MORE THAN 0.20 PER CENT, AND EITHER INSIDE OR OUTSIDE SLEEVES SHALL BE USED. IN EITHER CASE THE LAP OVER THE END OF EACH COURSE SHALL BE AT LEAST 4 TIMES THE SHELL THICKNESS.

SPECIFICATIONS FOR FUSION WELDING. In the rules published in the March, 1931, issue (page 230), an error appears in the fourth sentence of the paragraph headed "Longitudinal Joints" which should be corrected to read:

If of the lap type the throat dimension OF EACH of the TWO welds shall not be less than $^5/_8$ [$1^1/_4$] $T$, where $T$ represents the thickness of the plate.

PAR. CA-5. REPLACE PRESENT PARAGRAPH BY THE FOLLOWING:

CA-5. Cracks in riveted, welded, or expanded joints are generally attributable to steel of unsuitable quality, to excessive internal stresses in the plates caused by high riveting pressure, imperfect thermal or mechanical treatment during fabrication, unskilful or abusive treatment during the repair of leaky seams, also, to extremly severe operating conditions. Cracks from such causes are in general transcrystalline (across the grains) in character and occur both internally and externally to any joint in any section of a boiler.

Cracks of a different character may occur in highly stressed portions of a boiler where dissolved salts concentrate. These cracks, which are generally intercrystalline (around the grain) in character can only occur within riveted or other joints in a boiler, and are usually termed embrittlement. These cracks generally take place below the normal water level, but have appeared above the water level.

In all embrittlement cases the analysis of the concentrated boiler waters show that the sulphates are low in proportion to the combined sodium hydroxide and sodium carbonate.

In cases of boiler failures from cracks, competent advice should be secured to determine the cause for such failure.

Operating evidence supplemented by laboratory research work indicates that if not less than the following ratios of sodium sulphate to total alkalinity as determined by methyl orange are maintained in the boiler concentrates, embrittlement will not take place:

| Working Pressure of Boiler, Pounds Gage | Sodium Sulphate | to | Methyl Orange Alkalinity |
|---|---|---|---|
| 0 to 150 | 1 | to | 1 |
| 150 to 250 | 2 | to | 1 |
| 250 and over | 3 | to | 1 |

Extensive research work by a number of investigators has confirmed the necessity for the above ratios.*

Recent laboratory research work has indicated that there may be other means of preventing embrittlement. However, there are insufficient operating data available at the present time to prove the value of these preventative measures.

Pending further operating data from boilers in service, it is recommended that the requirements of Par. I-44 of Section VI of the Code be extended to all riveted, welded, or expanded joints, and that careful examination of all joints be made if leaks occur and do not remain tight after proper calking.

PAR. A-21*a*. REVISED:

*a* In Horizontal-Return Tubular Boilers—in the rear head, not less than 1 [2] in. above the upper row of tubes, the measurement to be taken from the line of upper surface of tubes to the center of the plug, and projecting through the sheet not less than 1 in. When the distance between the uppermost line of tubes and the top of the steam space is 13 in. or less, the bottom of the fusible plug may come at a lesser distance than 1 [2] in. above the upper row of tubes, but in no case shall the plug be located below the level of the top of the uppermost row of tubes.

* See Bulletin No. 216 of the Engineering Experimental Station, University of Illinois, entitled "Embrittlement in Boilers."

# A.S.M.E. Boiler Code Committee Work

**THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, 29 West 39th St., New York, N. Y.**

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and published in MECHANICAL ENGINEERING.

Below are given records of the interpretations of the Committee in Cases Nos. 607 (reopened), 674–679, inclusive, as formulated at the meeting on January 23, 1931, all having been approved by the Council. In accordance with established practice, names of inquirers have been omitted.

CASE NO. 607 (Reopened)

*Inquiry:* Is it permissible, under the Code for Unfired Pressure Vessels, to construct a spherical shell with lap joints, or is it required that butt strap joints be used?

*Reply:* While there is nothing in the present Code applying to the construction of spherical vessels, it is the opinion of the Committee that lap joints may be safely used in the construction thereof provided that if the plates exceed $^5/_8$ in. in thickness, they shall be hot formed to the proper curvature, and each vessel shall be carefully and completely fitted together in the shop before shipment.

CASE NO. 674

(In the hands of the Committee)

CASE NO. 675

*Inquiry:* Does the reply to section *a* of Case No. 661 permit the use of fusion welding of plain and wholly unstayed boiler furnaces under the conditions set forth?

*Reply:* The reply is intended to refer to the particular furnace under consideration and does not apply to plain and wholly unstayed boiler furnaces. Pending the time when the Proposed Specifications for Fusion Welding of Drums or Shells of Power Boilers are adopted, the Committee would recommend that requirements of these specifications or of the Proposed Specifications for Fusion Welding of Unfired Pressure Vessels for stress relief and free bend tests be followed for the particular furnace under consideration.

CASE NO. 676

(In the hands of the Committee)

CASE NO. 677

*Inquiry:* May the longitudinal seams of tanks for the storage of air or water under pressure at not to exceed 150 lb. per sq. in. be made under the rules of the Code for Unfired Pressure Vessels by using the electrical-resistance compression butt-weld method? This process of welding involves bringing the two edges of the sheet together at one point and applying locally and continuously a current of sufficient intensity to bring the edges to the welding temperature, and while the heated section is in a plastic condition, compressing the edges together so as to obtain thorough union thereof.

*Reply:* It is the opinion of the Committee that although this method of welding is not provided for in the Code, it may be used with safe results provided the material and construction of the tank come within the requirements of the Code and provided:

That the plate used for tanks for the purposes described and for this method of welding shall conform to Specifications S-2 for Steel Plates of Flange Quality for Forge Welding.

That this method be limited to the use of plate not over 0.135 in. thick.

That prior to the welding operation the edges of the plate and the electrical contact area shall be cleaned so as to free those surfaces from scale, oxides, or grease.

That the weld be made progressively and continuously over its entire length.

That the offset of the edges due to the compressing shall not exceed 60 per cent of the thickness of the plate.

That the prescribed tests for the hydrostatic pressure as specified in the Code are complied with.

That the unit stress shall not exceed 8000 lb. per sq. in.

A revision of the Code to cover the above is under consideration.

CASE NO. 678

*Inquiry:* May the heads of tanks for the storage of air or water under pressure not to exceed 150 lb. per sq. in. be inserted into the ends of the cylindrical shell, either concave or convex to pressure, and secured by fusing the edges of the shell to the head or the edges of the shell and head flange, under the rules of the Code?

*Reply:* It is the opinion of the Committee that although this method of construction is not provided for in the Code, if the shell plate does not exceed 0.135 in. in thickness and heads do not exceed 0.15 in. in thickness, tanks for the purpose described with heads inserted in the ends of the shells. either concave or convex to pressure, come within the requirements of the Code, provided:

That the heads are designed in accordance with Pars. U-36 to U-39 of the Code.

That the head concave to pressure is inserted so that not more than $^1/_8$ in. of shell projects beyond the point of tangency of the flange and knuckle before welding, and that the resulting valley is filled in with weld metal formed by fusing the projecting edge of the shell or/ and the introduction of extraneous metal.

That the head convex to pressure is inserted so that the edge of the flange is substantially flush with edge of the shell and the two thoroughly fused together, or as shown in Fig. U-7B, using fusion welding.

That the prescribed tests for the hydrostatic pressure as specified in the Code are complied with.

A revision of the Code to cover the above is under consideration.

CASE NO. 679

*Inquiry:* Where very large unfired pressure vessels are installed for use as gas holders, it is sometimes difficult, if not impossible, to test them under hydrostatic pressure, on account of the great weight of the mass of water required to fill them, which would require enormous foundations. A ruling is requested as to how the hydrostatic-pressure-test requirement should be treated in such cases?

*Reply:* A code of rules cannot be made which will effectively cover all sorts of constructions which may be contemplated. When it develops that there will be great difficulty in applying the hydrostatic test to an unfired pressure vessel on account of its size, the Committee recommends that this question be taken up with the local, state, or municipal authorities in charge of the enforcement of the Code with a view to dealing with that particular vessel as a special case.

It is the opinion of the Committee that the provisions in the Code for enameled vessels should be followed in a general way namely, that the working pressure be limited to 80 per cent of that for the same fusion-welded vessel if subjected to the hydrostatic test called for by Par. U-78, and the vessel be tested at the working pressure.

Compressed air may be used for testing the vessel at not to exceed the working pressure. Precautions should be taken to use a proper lubricant in the air compressor to avoid danger from an explosion through the ignition of vaporized oil in the compressed air.

# Correspondence

## Standardization of Machine Pins

TO THE EDITOR: The subject of standard machine pins is one which vitally affects every engineer whether he be in the designing or producing end of the profession. After having wallowed for the last three years in the present system of taper pins which uses the large end as the basic diameter, the writer anticipates with a feeling of relief the advent of the proposed new standards. Prior to that time we used the Brown and Sharpe standards, based on the small ends and requiring only one drill for each size, irrespective of length, but difficulties of purchasing these as regular stock forced us to change over.

While agreeing with most of the proposed new standards, the writer is of the opinion that the method of denominating the lengths of the pins is not very good. This applies to both the taper and cylindrical pins. When a workman, or any one else for that matter, measures the length of a square-ended pin he naturally takes the overall dimension, and this aspect is also considered in the newly established American standard for machine bolts, capscrews, etc. This gives the length from under a bolt head to the extreme tip, including the chamfer. The proposed new standard for machine pins gives the length of the parallel or taper portion, while the rounded ends are extra to the nominal length. The overall length of the pins will then become a motley assortment of dimensions owing to the added rounded ends being each one-quarter of the diameter of the small ends. For example, a $^5/_{32} \times 1^1/_2$-in. pin would be $1^{13}/_{64}$ in. long overall, or a $^5/_8 \times 2^3/_4$-in. pin would be $3^1/_{16}$ in. long overall. Rarely is it necessary to hold the taper portion of a pin closely to a definite length, and in fact when the dowel fits in a blind hole it is necessary to allow extra length for gripping with the extracting tool. The method

of dimensioning has followed the present system, and presumably the idea is that the radiused end is unimportant as not affecting the fitted length. However, the present system has the definite sharp edges of the chamfer from which to measure, and the chamfer itself is quite shallow. The new standard pins have a radiused corner which is rather vague for measuring purposes, but they have a very definite flat at both ends. Errors or wear of the radius tool will not affect the length if this is given as the overall dimension. The designer is usually interested in the overall length of a pin when considering clearances on machine components. There would be no more difficulty in establishing a standard series of lengths than as at present proposed.

A point not directly in line with the foregoing but decidedly allied to it is in consideration of taper reamers for the new standard taper pins. The Standards Committee, while not as yet proposing any standards for reamers, indicates that these will not be made so that each size overlaps, but each size will be one to itself as with cylindrical pins and reamers. One wonders if this will not make necessary the use of a "special" drill which is larger than the standard one for a given size of taper pin when limitations of space require the shortening of a standard reamer by removing some of the small end. In such a case it would be necessary to take the longest standard taper pin of that nominal size and remove its small end to fit the hole produced by the large end of the shortened reamer. The standard drilled hole is made to suit the small end of the standard reamer in the proposed new series.

Perhaps some will think the points raised above are relatively insignificant, but considering the immense number of machine pins used and also the fact that new standards are being set up which will be perpetuated through many years, it is certainly worth while to make every endeavor to have the standards as nearly perfectly practical and practically perfect as possible. To this end the writer suggests that engineers who are in agreement, or otherwise, with the foregoing write to Mr. Myron E. Steczynski, Chairman of the Sectional Committee on Machine Pins, care of the A.S.M.E., 29 West 39th Street, New York, N. Y., indicating their views. This body is inviting constructive comments from all interested before deciding the final form of the standards.

Auburn, N. Y. W. S. BROWN.[1]

## The Strength of Welded Bull Plugs

TO THE EDITOR:

In his paper entitled "The Strength of Welded Bull Plugs" in MECHANICAL ENGINEERING, October, 1930, Mr. Cornelius L. Hughes has given a most ingenious method for obtaining elastic curves, together with an interesting report on the ultimate strength of two types of pressure-vessel heads.

The outstanding feature of the experiments with the bonnet-head plugs is that five were ruptured at the top of the head, the one exception to rupture at this location being due to burnt metal within another portion of the weld. Hence we may conclude that the thin slice across the top of the bonnet head is its weakest section, due to the greater stress developed in the seam of this section.

This same section, however, is quite similar to a thin slice of a circular flat plate fixed at the edges and subjected to a uniform load. It would seem, therefore, that for pressures allowable for use with the bonnet head, it would have no particular advantage over a circular blank welded into the end of the pipe as shown in Fig. 1.

It is to be hoped that Mr. Hughes can carry out some additional tests on pipes dead-ended with welded flat plates in order to compare their strength with that of bonnet-head plugs.

Neither the bonnet head nor the blanked end should be permitted for any except very moderate pressures, because the weld is placed where compound stresses, possibly combined with impact, must be carried, resulting in severe bending stresses in the weld metal.

For the higher pressures, the writer would suggest the use of an ellipsoidal head as shown in Fig. 2. Although the ideal theoretical shape for the head of a pressure vessel is a hemisphere, as used in the orange-peel head, the ellipsoidal head (with correct ratio of major and minor axes) is to be preferred because of practical considerations. Moreover, when the section of the head is a true ellipse no bending occurs due to imposed stresses. While the orange-peel head has the ideal form, the intersection of welds has some disadvantages.

Mr. Hughes's paper leads the writer to suggest that both the orange-peel and bonnet heads are far too costly for either frequent or wide use. Some manufacturer of pipe fittings, if the need is made evident, will undoubtedly bring out standardized blanks

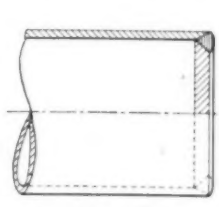

FIG. 1

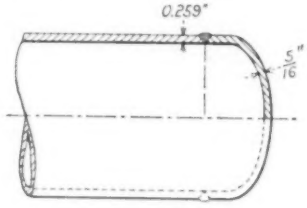


FIG. 2

similar to Fig. 1 to replace bonnet heads for low-pressure use, or ellipsoidal heads, Fig. 2, to replace orange-peel heads for all pressures, up to the maximum.

The use of templets, and the necessity of the expensive operations of cutting and beveling at different angles, of fitting bonnet heads, and of bending over orange-peel heads, can be obviated by these suggested stock fittings which require just one weld straight across the pipe.

Chicago, Ill. F. E. WERTHEIM.[2]

## Alloys of Iron Research

TO THE EDITOR:

Because of interest to readers of MECHANICAL ENGINEERING, you may like to have information to the end of 1930 on the Alloys of Iron Research, under the auspices of The Engineering Foundation, mentioned on page 70 of your January issue. The subscriptions to date for the five-year program total $230,000, and all annual installments due have been paid.

On December 31, 1930, 1700 technical articles had been reviewed and 4500 abstracts made. In addition, an annotated and classified bibliography on iron-silicon since 1890 has been prepared for participants in the enterprise; it is believed to be as complete as it is practicable to make such a bibliography. Work for the Iron Alloys Committee is progressing vigorously, not alone in the New York office of The Engineering Foundation, but also at Battelle Memorial Institute, Columbus, Ohio, National Bureau of Standards, Washington, Carnegie Institute of Technology, Pittsburgh, and Lehigh University, Bethlehem, Pa.

New York, N. Y. ALFRED D. FLINN.[3]

[1] M. E., McIntosh & Seymour Corp. Mem. A.S.M.E.

[2] Assoc-Mem. A.S.M.E.

[3] Director, The Engineering Foundation.

# American Standard Safety Code for Elevators

## 1931 Revision by Sectional Committee

THE second revision of the American Standard Safety Code for Elevators has been completed and is now before the sponsor organizations for approval. The first revision was approved by the American Standards Association in April, 1925, the first edition of this code having been approved and published in 1921.

The Sectional Committee on Safety Code for Elevators was organized under the procedure of the American Standards Association with the American Institute of Architects, the U. S. Bureau of Standards, and The American Society of Mechanical Engineers as joint sponsors. This Sectional Committee was appointed to revise and extend the Code originally developed by the A.S.M.E. Committee. The present Committee consists of 36 representatives of 22 national organizations. Its officers are: Chairman, Sullivan W. Jones, Architect; Vice-Chairman, Orrie P. Cummings; Vice-President, A. B. See Elevator Company; and Secretary, John A. Dickinson, Bureau of Standards.

At the time the 1925 revision was in progress the Committee needed certain information and data which could only be supplied by research. It accordingly organized a Special Subcommittee on Research, Interpretations, and Recommendations. This subcommittee has made a study of the functions and operation of elevator safeties and buffers and their associated mechanisms, and has developed methods of test for the approval of elevator safety devices. The two manufacturers' associations cooperated completely in this investigation, subscribing the necessary $67,000 to cover the expenses. Most of them have also submitted their buffers and other safety devices for test.

The Code is intended as a guide to state and municipal authorities in the drafting of their regulations, and it may be adapted in whole or in part. It is intended also for use as a standard reference for safety requirements for the use of elevator manufacturers, architects, and consulting engineers, and as a standard of practice for use by hotels, department stores, office buildings, and other users of elevators through voluntary application.

This latest revision follows the form and arrangement of the second edition quite closely, although a considerable amount of new material has been added in several places—notably under definitions and the various sections covering safeties, terminal stopping devices, buffers, and interlocks. The definitions are included in the Code for the convenience of the industry, and it is hoped that in this way a certain amount of standardization of the nomenclature of the various systems of control and operation will be accomplished. During this revision the national committee has had the benefit of complete interchange of ideas with the members of the committee which are at work on the revision of New York City's Elevator Code.

The system of key numbers used in the previous edition has been continued. They indicate whether a rule should be made retroactive, and if so, how long a period after the adoption of the Code should be allowed to bring the equipment in question up to the Code requirements.

In the introductory notes the committee calls attention to the use of elevators as emergency exits from tall buildings, stating that the elevator must be recognized as the main, and often the only, practical means of exit in case of emergency, because of the necessarily inadequate stairways.

In addition to the general introduction, the scope and purpose, and definitions, the Code is divided into seven parts: (1) Hoistway Construction for Passenger and Freight Elevators and for Dumbwaiters; (2) Power Passenger Elevators; (3) Power Freight Elevators; (4) Hand Elevators; (5) Dumbwaiters; (6) Escalators; and (7) Rules for Inspection, Maintenance, and Operation.

Following are some examples of the revised paragraphs. Those desiring to review the entire Code are requested to apply to C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

### DEFINITIONS

*Hoistway-Door Interlock.* A hoistway-door interlock is a device, the purpose of which is:

First: To prevent the operation of the elevator machine in a direction to move the car away from a landing unless the hoistway door at that landing at which the car is stopping or is at rest is locked in the closed position.

Second: To prevent the opening of the hoistway door from the landing side except by special key; unless the car is at rest within the landing zone, or is coasting through the landing zone with its operating device in the stop position.

Door Unit System is an interlock system which meets the requirements of the interlock definition above, but does not require all the hoistway doors to be locked in the closed position.

Hoistway Unit System is an interlock system which, in addition to fulfilling the requirements given under the definition of interlock, will also prevent the operation of the car unless all hoistway doors are locked in the closed position . . . .

### PART I HOISTWAY CONSTRUCTION

#### Rule 103 Pits, Overtravel, and Clearances (1)

*c* When the counterweight rests on its fully compressed buffer, the clear distance between the top of the crosshead of the car and the corresponding point of any obstruction in the upper limit of the hoistway vertically above it shall be not less than the sum of the following:

1 Two (2) feet
2 One-half the buffer stroke is determined by Rule 201a
3 Two (2) inches per hundred feet of travel,

provided that when the car crosshead is two (2) feet from the nearest obstruction above it, no projection on the car shall strike any part of the overhead structure.

If provision is made to eliminate the jump of the car at a buffer engagement, item 2 is to be omitted.

When the car is resting on the fully compressed buffer, the clearance above the counterweight shall be the same as that specified above for the car, except that item 1 is to be omitted.

To determine the minimum top overtravel of platform elevators, the maximum height of material to be handled, but in no case less than six (6) feet, shall be added to the clearance as determined by the above formula. (See also Rules 215f and 222c.)

#### Rule 120 Hoistway Doors for Passenger Elevators

*c* The distance between the hoistway side of the landing door opposite the car opening and the hoistway edge of the landing threshold shall be not more than four (4) inches. (1)

For automatic-operation elevators the distance between the hoistway side of the landing door opposite the car opening and the hoistway edge of the landing threshold shall be not more than one (1) inch for swinging doors and two (2) inches for sliding doors. (1)

For existing installations of automatic-operation elevators where the clearance exceeds one and one-half ($1^1/_2$) inches for swinging doors or two and one-half ($2^1/_2$) inches for sliding doors, the space between the hoistway side of the landing door and the hoistway edge of the landing threshold shall be filled in by suitable means. (0)

If the door slides in two or more sections, the specified dimension applies to that section which closes against the lock jamb. (1)

No hardware, except that required for interlocking, indicator and signal devices, shall project into the hoistway beyond the line of the landing threshold. The lower edge of the interlocking devices shall be beveled as required in Rule 101f. (24)

# Symbols for Mechanics, Structural Engineering, and Testing Materials

## Proposed American Standard

THE set of symbols given below is the ninth to be proposed as an American Standard. This proposal, now before the sponsors for approval, has been formulated under the procedure of the American Standards Association with the American Association for the Advancement of Science, American Institute of Electrical Engineers, American Society of Civil Engineers, Society for the Promotion of Engineering Education, and The American Society of Mechanical Engineers as co-sponsors. The Sectional Committee on Scientific and Engineering Symbols and Abbreviations was organized in January, 1926, and now consists of thirty-four members representing thirty-seven national organizations. Dr. J. Franklin Meyer, Physicist, Bureau of Standards, is its chairman and Mr. Preston S. Millar, General Manager, Electrical Testing Laboratories, acts as its secretary. Since the organization of the Sectional Committee eight of its nine subcommittees have completed and published standard symbols for Hydraulics, Heat and Thermodynamics, Photometry and Illumination, Aeronautics, Mathematics, Letter Symbols for Electrical Quantities, Graphical Symbols for Telephone and Telegraph Use, and Navigational and Topographical Symbols. At the present time two other proposals of the Subcommittees are well along toward completion. These cover Abbreviations for Scientific and Engineering Terms, and Graphical Symbols for Radio Communication.

The proposed symbols listed below were developed by Subcommittee No. 1 under the chairmanship of John T. Faig, President, Ohio Mechanics Institute, Cincinnati, Ohio. Should you be interested in commenting on them, your letter should be addressed to C. B. LePage, Assistant Secretary, A.S.M.E., 29 West 39th Street, New York, N. Y.

### Complete List of Proposed Standard Symbols

| | |
|---|---|
| Acceleration, angular | $\alpha$ (alpha) |
| Acceleration, due to gravity | $g$ |
| Acceleration, linear | $a$ |
| Angular distance | $\theta$ (theta) |
| Angular velocity | $\omega$ (omega) |
| Area | $A$ |
| Axes, through any point | $X$-$X$ |
| | $Y$-$Y$ |
| | $Z$-$Z$ |
| Breadth | $b$ |
| Center of rotation | $O$ |
| Coefficient of sliding friction | $f$ |
| Concentrated load (same as force) | $F$ |
| Constants | $C$ |
| Curvature, radius of | $\rho$ (rho) |
| Deflection | $y$ |
| Deflection of a panel point of a truss | $\Delta$ (delta) |
| Density | $\rho$ (rho) or $d$ |
| Depth | $d$ |
| Diameter | $D$ |
| Distance, linear | $s$ |
| Eccentricity of application of load | $e$ |
| Efficiency (hydraulic, mechanical, volumetric) | $e_h$, $e_m$, $e_v$ |
| Elasticity, modulus of | $E$ |
| Elongation, unit | $\delta$ (delta) |
| Force | $F$ |
| Force in any bar of a framed structure due to a load of unity applied at any point in any direction | $u$ |
| Frequency (harmonic motion) | $f$ or $n$ |
| Gyration, radius of | $k$ |
| Head | $H$ or $h$ |
| Height | $h$ |
| Inertia, rectangular moment of | $I$ |
| Inertia, polar moment of | $J$ |
| Length | $L$ |
| Load per unit distance | $w$ |
| Load, total | $W$ |
| Mass | $m$ |
| Modulus of rupture | $R$ |
| Moment in inch-pounds at any section of a girder due to the moment of one inch-pound applied to the girder at any point | $m$ |
| Moment of force, including bending moment | $M$ |
| Neutral axis, distance to extreme fiber | $c$ |
| Number of revolutions per unit of time | $n$ |
| Period (harmonic motion) | $T$ |
| Power, horsepower | $P$ |
| Pressure per unit of area | $p$ |
| Radius | $r$ |
| Ratio between modulus of elasticity of steel and modulus of elasticity of concrete | $n$ |
| Ratio of the distance from the neutral axis to the outer fiber of a reinforced-concrete beam to the distance from the outer fiber to the point of application of the resultant tensile stress | $k$ |
| Ratio of the lever arm of the resisting couple in a reinforced-concrete beam to the distance between the outer compressive fiber and the point of application of the resultant tensile stress | $j$ |
| Reactions | $R$ |
| Section modulus | $Z$ or $S$ |
| Statical moment of any area about a given axis | $Q$ |
| Steel ratio, in reinforced-concrete beams | $p$ |
| Stress, unit | $s$ |
| Stress, unit compressive | $s_c$ |
| Stress, unit tensile | $s_t$ |
| Stress, unit shear | $s_s$ |
| Stress, total tensile or total steel, in reinforced concrete | $T$ |
| Stress, total compressive or total concrete, in reinforced concrete | $C$ |
| Stress, total shear | $V$ |
| Stress, unit concrete, in reinforced concrete | $f_c$ |
| Stress, unit steel, in reinforced concrete | $f_s$ |
| Stress, unit shear of concrete | $v$ |
| Temperature, absolute | $T$ |
| Temperature, ordinary | $t$ |
| Thickness | $d$ or $t$ |
| Time | $t$ |
| Torque | $T$ |
| Velocity, linear | $V$ or $v$ |
| Volume | $V$ |
| Work, or energy | $W$ |

# Engineering and Industrial Standardization

## A.S.A. Approves Safety Code for Lighting Factories

A REVISION of the "Code for Lighting Factories, Mills, and Other Work Places" (A 11-1930), which has been developed under the sponsorship of the Illuminating Engineering Society, has been approved by the A.S.A. Standards Council as an American Standard. Changes have been made in many of the recommended values and in specifications for illumination for different classes of work.

The true importance of the code is difficult to estimate, inasmuch as statistics on accidents frequently do not mention the cause of the accident. According to a recent statement by Lucian W. Chaney, of the Bureau of Labor Statistics, however, improper lighting of factories, mills, and other work places results annually in a considerable loss to industry through accidents and decreased efficiency. With the provision of proper illumination greater output can usually be obtained for the same labor cost, while decreased errors and fewer imperfections make for a better quality of goods.

An estimate of the cost of good illumination and of the savings to be effected by the use of proper lighting, included in the code, assumes that one 100-watt incandescent electric lamp will take care of one operator; that the lamp burns on the average of two hours per day, 300 days per year; that the life of the lamp is 1000 burning hours; and that the operator works eight hours per day, 300 days per year, at 45 cents per hour. The total cost of maintaining good illumination, including the investment and the annual operating cost, is placed at $6.11 per man per year. The cost of labor (the annual wages per man per year) is estimated at $1080. If an operator, because of good illumination, saves in production or in better quality of product the equivalent of only three minutes per day for 300 days, he will offset the annual cost of the illumination, according to the foregoing estimate.

Copies of the code are available for loan or purchase through the A.S.A. Information Service, 29 West 39th Street, New York. The price per copy is 20 cents.

## International Standardization of Sieves for Testing Purposes

THE organization of a sectional committee to establish standard specifications for sieves for testing purposes, under the auspices of the American Standards Association, has been requested by the American Society for Testing Materials. The Society proposes to offer, as a working basis for consideration of an A.S.A. technical committee, the A.S.T.M. specifications on this subject which were developed in cooperation with the Bureau of Standards in 1926. The Bureau joins with the A.S.T.M. in the offer to assume joint sponsorship in the work of a sectional committee. The request of the American Society for Testing Materials has a bearing also on important international developments in this particular field, which have long been under discussion.

A technical committee was appointed under the auspices of the International Standards Association—of which body the American Standards Association is a member—and work on the subject of testing sieves was taken up some time ago, the international secretariat being entrusted to the Polish national standardizing body. The A.S.A. has informally cooperated in this work by supplying the I.S.A. technical committee on sieves with information regarding the situation in the United States. If an A.S.A. technical committee on sieves is appointed it seems probable that this committee will wish to cooperate in the international work.

Progress of the international work was discussed at a technical conference held under I.S.A. auspices in Vienna in September, 1930. It was agreed on this occassion that testing sieves would be defined as sieves used for testing the fineness of the material to be sifted, but not as sieves used for testing the working sieves. Although the testing sieves and the working sieves are required to have the same width of mesh, the conference agreed that the wire diameter of a working sieve and the corresponding testing sieve need not be the same. It appeared that in Germany test sieves were frequently used as working sieves because of their greater accuracy, as the price of testing sieves is not very greatly above that for working sieves.

A proposal for a series of standard testing sieves believed to be internationally acceptable will be submitted to all member-bodies of the I.S.A. when it has been worked out by the Polish secretariat, and laid by the A.S.A. before the sectional committee on sieves, if it turns out that such a committee is appointed. The American interests will then be asked to submit criticism and comments on the proposal and make such counter-proposals as they see fit, reflecting the position on the subject in the United States.

### NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the month of February 15–March 15, 1931:

**Symbols for Heat and Thermodynamics (Z 10c).** (American Tentative Standard.)

Sponsored by the American Association for the Advancement of Science, American Institute of Electrical Engineers, American Society of Civil Engineers, The American Society of Mechanical Engineers, and Society for the Promotion of Engineering Education. Published by The American Society of Mechanical Engineers.

**Specifications for Refined Wrought-Iron Bars (Revision of G 12-1923).** (American Tentative Standard.)

Sponsored by the American Society for Testing Materials. Published by the American Society for Testing Materials.

**Specifications for Wrought-Iron Plates (Revision of G 13-1923).** (American Tentative Standard.)

Sponsored by the American Society for Testing Materials. Published by the American Society for Testing Materials.

# MECHANICAL ENGINEERING

**A Monthly Journal Containing a Review of Progress and Attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers, and Proceedings of**

**The American Society of Mechanical Engineers**

**29 West 39th Street, New York**

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## The Process Industries

MANY of the industries of today are founded upon processes, and in this respect they are fundamentally different from manufacturing industries that produce textiles, shoes, radios, typewriters, automobiles, and the like. They are well illustrated by the chemical industries, by rubber, paint, leather, foodstuffs, paper, and petroleum. Machinery, materials-handling, power, production, management, and maintenance problems for these industries contain the common elements of which mechanical engineering for every type of industry is composed, and hence these industries, even though closely allied to the chemical or other fields, require mechanical engineers.

Recognition of this broad field for the services of mechanical engineers has for a long time urged those associated with these industries to organize themselves for the discussion of the mechanical-engineering problems of the process industries. A step in this direction was taken last December during the Annual Meeting of the A.S.M.E., when a Process Industries Committee was formed. It is the hope of those interested in this committee that its activities will eventually warrant the establishment of a Process Division of the A.S.M.E. Meetings with programs devoted to the process industries have been held successfully by some of the A.S.M.E. local sections, notably in Buffalo.

The Process Industries Committee has already made a logical and extremely valuable contact with the American Institute of Chemical Engineers. As evidence of the spirit of cooperation between these two groups, arrangements have been made for the Committee to participate in the Swampscott meeting of the A.I.C.E. A joint paper and program committee has been set up to arrange not only for the program of the Swampscott meeting but also for sessions at future meetings of the two societies.

Mechanical engineers associated with the process industries will heartily approve of the efforts that are being made to stimulate interest in this field. Active cooperation in the program of the Process Industries Committee is urged as an indication of interest in its work.

## Safety in Machine Design

NO MACHINE is properly designed unless it has been made reasonably safe. Safety, in other words, is an essential feature of machine design, not an afterthought.

To accomplish the major function for which his machine is intended is the primary object of the designer. Lucky he is if he succeeds in this, and, in general, many are the designs that he develops before there appears one that finally proves satisfactory for commercial use. The operator and customer have a right to expect that this design shall have incorporated in it safety features that will make any additional protective devices unnecessary.

Thus the safety idea, so important in the shop where the machine is used, must reach back into the drafting room and to the technical school where principles of design are taught and put into practice. There is a rich technical literature on safety devices for protecting machine operators. If the schools and drafting rooms do their work properly, safety would be so fundamental an objective in the minds of designers that reasonably safe and foolproof machines would be universal. Some of the machine-tool designers have developed the safety idea remarkably well. The modern lathe, for instance, has many more gears than the lathe of thirty years ago, yet these gears are so thoroughly enclosed that the modern machine is much less of a hazard than was the older one. It should be a major responsibility of teachers of machine design to awaken the consciousness of their students to the problem of safety in machine design to the end that they will never be satisfied with unsafe designs.

## Central-Station Services

EARLY in the development of electric lighting, Edison realized that if it was to become a commercial success, central-station distribution would be necessary. Since that time there has been a growing tendency to centralize the services that have become essential to the living of the modern man in the larger cities. Gas is supplied through pipes even to the humblest home. Water is obtained only from a central reservoir; hot water is distributed from a central heater to the tenants of a building. A central source of steam or hot water for heating office and apartment buildings is found in many cities and if heat can be supplied from a central source there is no reason why refrigeration should not be so supplied, as it is to a limited extent in some cities, because refrigeration is becoming a vital part of the equipment of the modern home. The principal questions involved in a district refrigeration system, however, are economic and commercial rather than engineering in their nature.

In the field of domestic refrigeration, changes have been rapid during the last few years. It was not so long ago that refrigeration for the preservation of foods was provided by means of ice, which with all its other defects had the advantage of never getting out of order. The development of electric and gas refrigerators of small size has not only created a big industry but has also modified to some extent the food habits of the nation. By making it possible to keep foods at lower temperatures than could have been done with a cake of ice and by means of an easy control of refrigeration, it has become possible to make cold

dishes and to preserve conveniently foods which spoil easily without adequate refrigeration, The most serious objection to domestic mechanical refrigeration is its comparatively high cost, but even this has been reduced now in many instances where apartment houses and residential hotels have installed domestic refrigerators as part of the equipment, so that all that the tenants have to do is to pay their gas or electric bills, which appear to be quite moderate. Presumably if central-station refrigeration develops, the refrigerator will be as much a part of the rental system as hot and cold water are today.

The Russian Soviet government is said to be seriously considering a plan that will provide community kitchens in cities, the idea being to cook all food in these kitchens and deliver it in heat-insulated containers. Just how far this tendency toward centralization of services essential to modern living will go, remains to be seen. It is clear, however, that we are far from the end of it as yet, and that the engineer with his lower costs of production in central stations is making it possible.

## A Study of Human Relations

FOR many years human knowledge has been rapidly expanded by thousands of specialists who have devoted their time and intellects to research and study. Whatever other use this vast accumulation of knowledge may have, its chief value lies in the possibility of improving the welfare and culture of man and of increasing his happiness and understanding. The physical sciences contribute to the material comforts and extend man's power and control over his physical environment. The biological and medical sciences serve his health. The political and social sciences assist him in his contacts with his fellow-men and his understanding of them. Had one individual all of this knowledge and the ability to put it to practical use, he would be a superman. Were every man so endowed, the millenium would indeed be attained.

The rich potentialities that lie in the judicious use of the entire sum of human knowledge can best be realized by agencies fitted to integrate its numerous specialties. Without such integration the zeal of the specialist is frequently misapplied and his knowledge frequently put to no use. A course of action which seems to be sound to an economist or an engineer may be fraught with serious social consequences, or involve a violation of biological law. The invention of machinery and of mechanical power precipitated an industrial revolution whose problems are still unsolved. Rapid, safe, and economical transportation and communication have resulted in political and ethnological disturbances. While the difficulties of the past would not have been entirely avoided by intelligent foresight and preplanning, a concerted study of them from all points of view is more likely to accelerate their elimination than is a happy-go-lucky faculty for muddling through.

It was an appreciation of the value of a well-rounded and competently informed attack on the problems of modern life that prompted the formation of the Institute of Human Relations at Yale University. Although at first emphasis seemed to be placed on medical, biological, psychological, psychiatric, and legal aspects of the problem, it was soon realized that an important phase of the venture lay in the industrial field, and that engineers must be included in the groups of specialists. An announcement in the *A.S.M.E. News* for February 7, 1931, now tells of the appointment of the advisory committee of the A.S.M.E. to work in cooperation with the Institute.

We have frequently called attention in these columns to the extra-technological obligations of the engineer. In its cooperative endeavor with the Institute of Human Relations the engineering profession has recognized these obligations and has shown its willingness to contribute its special knowledge to well-organized and intelligently administered attempts to solve some of the problems that vex our civilization. Great social benefits will result from this cooperation of engineers with the other learned professions.

## Improvements in Flying Conditions

NOW that the main problem of flying—ability to reach one's destination with reasonable safety and at high speed—has been solved, more and more attention is being devoted to the improvement of flying conditions in general. A number of obstacles to best flying performance still exist, and the industry has reached the stage today where these obstacles must be overcome.

One trouble encountered by fliers is that of losing their way. Up to a certain point the compass can be used, but greater assurance and accuracy in keeping on a course were acquired at a comparatively early date through the marking of towns and airports. This at first was done in a haphazard manner, but the time has now come for developing a proper and uniform system. As a result of extensive studies and service tests made by a special committee organized to study the subject, the Department of Commerce through its Aeronautics Branch has issued a bulletin describing a recommended standard system of airway marking that, it is said, will convey the necessary information to pilots in the simplest and most effective manner.

The purpose of the markings is to give the pilot his position and enable him to orient himself; they should also indicate the direction and distance to the nearest landing field, the size of the field, and the general equipment and facilities available, including facilities for night operation, as well as those available for land planes, seaplanes, or both.

In this connection the subject of searchlights might be mentioned. That properly installed and operated searchlights such, for example, as those used by regular air fields are a tremendous help to aviation, there can be no question. The same cannot be said, however, about searchlights on top of hotels, department stores, etc. Intended as a help to air traffic, they are nevertheless often more of a nuisance than a help, and the time has come when, if official action cannot be taken, at least an appeal should be made to those contemplating the installation of such searchlights to confer first with the local aeronautical authorities of the Department of Commerce with a view to making these searchlights as helpful as possible, or at least as harmless as possible.

There is another element in air traffic to which serious attention will have to be devoted at the earliest possible moment. This is the study of airplane noises. As long as air traffic was limited in volume and was carried on in a more or less sporadic manner and in the daytime only, those living in the vicinity of air fields were willing to put up with the nuisance of the noise. Now, however, that some fields have become very busy places and night flying is developing on a constantly growing scale, there have been vigorous objections to the noise.

To meet this situation a study of engine mufflers as a means of reducing airplane-engine exhaust noises has been undertaken by the Aeronautics Branch of the Department of Commerce as a part of its investigation of the reduction of airplane noises generally For this investigation there has been secured a 180-hp. 1800-r.p.m. model-E Hispano-Suiza water-cooled aircraft engine with a hydraulic dynamometer to absorb the power. This is important as it permits eliminating the noise of the propeller. While engine-exhaust noise forms only a part of the din made by an airplane, it should nevertheless be the first to receive attention because it is easiest to eliminate.

## A.S.M.E. Fuels Meeting

CERTAIN features of the Fourth National Fuels Meeting of the A.S.M.E., held in Chicago, February 11 to 13, in connection with the Fifth Midwest Power Engineering Conference and the Fifth Midwest Power Exposition, are worthy of brief mention. There was an undoubted logic in the decision to hold this year's meeting in the Midwest and in connection with the biennial power conference. Particularly this year the economy of taking in both events in one trip was appreciated by many. The slight overlap of simultaneous sessions was unavoidable, but not particularly serious as care was taken to schedule together topics having widely different appeals.

Fuels technology seems to be progressing without any startling developments since the advent of pulverized coal. Stokers, except the small type, were not discussed, but a growing interest in the small stoker was evident, not only at the sessions but in the exhibits at the Power Show. The invasion that oil and gas have made into the coal producers' business is being countered by an attempt to give greater satisfaction in the use of coal by means of stokers and a well-organized coal-dealers' service.

Developments in pulverized-coal firing, and problems related thereto, continue to demand attention and were productive of much valuable data presented in papers by those whose experiences give them authority to speak. In this connection the paper by E. H. Tenney on the "Effect of Fineness of Pulverization on Boiler Efficiencies," and the one by A. L. Baker on "Slag-Tap Furnaces," deserve especial mention and commendation. Refinery-waste fuels, discussed by H. J. Klotz, and conversion of coal-fired boilers to gas firing, discussed by W. D. Edwards, represent other fuel problems that are in the engineering mind.

Carbonization, a fruitful source of discussion in recent years, was represented by a luncheon address on "Recent Developments in Bituminous-Coal By-Products," by A. C. Fieldner. Maj. Max Toltz described a new process of dehydrating low-grade coal, and E. L. McDonald, who, by the way, made an excellent presentation of his subject, told how Missouri-Kansas coals had been improved by greater care in mining methods, and showed how the furnaces in which they are burned had developed from year to year. Numerous other papers, many of which are to be published, were presented and discussed.

It is unfortunate that such a fundamental subject as radiation in boiler furnaces is so little understood by engineers that they did not adequately discuss the paper on this subject by N. Artsay. Touching as it does the realm of pure physics, this subject is none the less important to practical men, who would probably gain much by a thorough study of the theoretical principles involved in the light of their wide experiential knowledge.

Geo. A. Orrok's paper on the boiler plant of the future, printed in the March issue of MECHANICAL ENGINEERING, also found engineers unwilling to commit themselves on speculative and possibly controversial trends in engineering progress—a cautious attitude that may avoid future embarrassment in event predictions fail to materialize, but a discouraging one to those who feel that a look ahead, with the perspective of the past as a guide, serves a useful purpose.

In many ways, most significant of all was the closing session of the meeting, devoted to a smoke-abatement conference. One is impressed with the breadth and depth of the air-pollution problem and with the lack of solid ground on which to advance toward its satisfactory solution. There is conflicting testimony about the extent and seriousness of the nuisance when considered from many and widely different points of view. Health, esthetics, economics, politics, engineering, sociology, law, all seem to be involved, and it would be difficult to predict which of these, in a given locality, will be the dominant factor when the issue becomes a major one. Naturally engineers consider the problem as belonging chiefly to the engineer, and would like it to remain so. To this end they are willing to take the initiative, as they should. The newly organized Air Pollution Committee of the A.S.M.E. Fuels Division, under the aggressive leadership of Ely C. Hutchinson, has already begun its attack on the problem. Mr. Hutchinson's discussion at the Chicago meeting met with enthusiastic applause and expressions of approval. The engineering profession must stand squarely behind him and his committee.

## Commemorative Aeronautic Meeting

AVIATION suffered heavy losses during 1930 through the deaths of three of its eminent pioneers and patrons—Glenn H. Curtiss, whose name is intimately associated with successful experimentation and achievement in airplane design and construction during the infancy of heavier-than-air-craft development; Chance M. Vought, cut off at the height of his career as a skilful designer and successful manufacturer who combined sound aeronautical engineering skill with an artistic sense of line, form, and proportion; and Daniel Guggenheim, financier, developer of mining projects, and philanthropist, whose faith in the future of aviation led him to become its patron and to provide a fund of nearly three million dollars by means of which encouragement and support have been given to those interested in the technological development of the art of flying.

It was in honor of these three men that a Commemorative Aeronautic Meeting was held at the Engineering Societies Building, New York, on February 25 under the joint sponsorship of the Aeronautical Chamber of Commerce of America, the American Institute of Electrical Engineers, the American Institute of Mining and Metallurgical Engineers, the American Society of Civil Engineers, The American Society of Mechanical Engineers, The National Aeronautic Association, and the Society of Automotive Engineers.

In his introductory address at the meeting, Roy V. Wright, president, A.S.M.E., recalled the faith engineers had expressed in aviation long before it had been successfully demonstrated that man could fly in a mechanically propelled heavier-than-air machine. The first president of the A.S.M.E., Robert Henry Thurston, in his address to the Society in 1881, dwelt at some length on the probability of successful flights by airplanes, as did George H. Babcock, also in a presidential address to the A.S.M.E., in 1887. Both of these engineers recognized that the problem of designing a light-weight, dependable, and powerful engine was one inextricably involved in the problem of aerial flight.

President Wright recalled the deaths, also in 1930, of Elmer A. Sperry, Charles Matthews Manly, and Capt. L. M. Woolson, whose names are inevitably associated with aviation. Mr. Sperry, developer of the gyroscope for commercial uses, and prolific inventor, became interested in aviation through his son, the late Lawrence Sperry, with whom he developed many instruments and devices for the safe handling of airplanes. Mr. Manly had been the associate of Dr. Samuel Pierpont Langley, for whose aerodrome, wrecked in attempts to fly it in 1903, he had constructed a remarkably light-weight radial internal-combustion engine. Captain Woolson, whose death came in an airplane accident in April, 1930, was the designer of a 9-cylinder, air-cooled, radial aeronautical Diesel engine, a type that greatly reduces the fire hazard in aircraft. Col. V. E. Clark, as chairman of the meeting, introduced the speakers who recounted the achievements of the three men who were being honored. The contributions of Glenn H. Curtiss to aeronautics and the principal events of his career were dramatically told by Frank Russell, former vice-

(Continued on page 321)

# Sir Charles Algernon Parsons

1854–1931

SIR CHARLES A. PARSONS

PIONEER in steam-turbine engineering, honorary member of many engineering societies, including The American Society of Mechanical Engineers, and the first engineer to receive the Order of Merit, the Hon. Sir Charles Algernon Parsons died February 11, 1931, while on a cruise to the West Indies. He was 76 years old, and through his death engineering science and industry loses a leader and pioneer. More than any other person, by his development of the steam turbine he has contributed to the greatest advance in steam practice since the advent of the steam engine. He was not the first to conceive of a rotary steam prime mover, but due to his labor and ingenuity the steam turbine became the prime mover for the generation of electricity in the largest power stations, and for the propulsion of the largest and fastest ships. He had a very broad knowledge of scientific activities, was very sympathetic in his nature, and a most agreeable and interesting companion.

The scientific bent in Sir Charles was in some measure hereditary, and was nurtured under his distinguished father, the Earl of Rosse, of astronomical fame. From his birth, July 13, 1854, he lived in a scientific environment, for Birr Castle was an open house to men of high achievement. Sir Charles learned the principles of mechanical construction from his father, and also had a succession of distinguished tutors. After a short period at Dublin University he entered St. John's College, Cambridge, at the age of 19. His three-year course terminated with the winning of high honors as eleventh wrangler in the Mathematical Tripos of 1876. He next became pupil apprentice at Armstrong's works at Elswick, where he continued for four years. His brilliance as a scientist and technician thus had a practical foundation, and he attained mechanical skill of a high order. Later in the development of his inventions he was capable of taking the tools from a workman's hand and showing him how to do the job. As an apprentice he invented several things, among which were valve motions and a four-cylinder epicycloidal rotary engine with revolving cylinders which were then manufactured by Messrs. Kitson, of Leeds. It then followed naturally that with the termination of his apprenticeship he should join the latter firm, where he continued for two years, his chief work being on the propulsion of torpedoes by rockets.

In 1883 Sir Charles became a partner in the firm of Clark, Chapman, and Company, and shortly after began experimenting with the steam turbine about one year after it had been invented by de Laval of Sweden. Sir Charles devised the scheme of compounding the blading, and developed the reaction turbine in which steam flows through a series of alternate stationary and moving blades of similar form. By this arrangement he was able to reduce the speed of the rotor so that higher efficiencies could be obtained at speeds much more practical than had been possible in the de Laval turbines. It was due to this invention and to his subsequent activities that the steam turbine became of such commercial importance, and which made possible the building of turbines in large sizes.

The turbine blades at first were milled out of the solid metal on the periphery of brass rings, a construction subsequently superseded by one more perfect, in which the blades were set and wedged with distance pieces in rings with their roots in grooves on the drum and on the casing, as is now a familiar construction. At that time dynamo construction was in its infancy and the speeds necessary had a great influence on the design of the steam turbine and added to the problems that had to be solved. Sir Charles believed that there was a great future for the supply of electricity, and he knew that its generation was then limited and ever would remain so unless the limitations of the reciprocating engine were overcome. He had in mind a prime mover of small dimensions, naturally balanced, which could run at the speeds necessary for efficient dynamos. It was the combination of steam turbine with dynamo that led to his success, and although the first turbines were less efficient than the reciprocating engine, its particular qualities for dynamo driving compensated for the loss. The steam turbine has now entered the entire field of the steam engine, and is the parent of a large family of high-speed devices designed particularly to take advantage of the characteristics which it affords.

The first Parsons steam turbine was completed in 1883. It was a 4-kw. machine with a series of rotating wheels, each complete in itself and corresponding to a parallel-flow water turbine. The mechanical difficulties were great, but they were overcome. The steam consumption of the first turbine was about 200 lb. per kw-hr., with a pressure of only 60 lb. per sq. in. This type of machine continued to be built for six years in small sizes for running dynamos, the largest machine being of only 100 hp.

The dissolution of partnership in the firm of Clark, Chapman, Parsons, and Company deprived Sir Charles of his patent rights. However, he established his own turbine and dynamo works at Heaton-on-Tyne, and there continued for five years experiments toward producing a radial-flow turbine, although recognizing that his original invention, based on a parallel-flow system, was preferable. In 1892 he constructed a radial-flow turbine of 100 kw. output which consumed but 27 lb. of steam per kw-hr. In 1894 he purchased his original patent rights, and from then on advance was rapid.

By 1895 steam-turbine developments had attracted considerable interest in the United States, and a license agreement for building Parsons steam turbines for land purposes was entered into by the Westinghouse Company. About this time the principal shipbuilders also secured a license for turbines applicable to marine propulsion. In 1905 the Allis-Chalmers Company also secured a license. These licenses have been renewed from time to time, and the companies have continued to enjoy the advantages of technical information from Sir Charles's organization.

In 1913 Sir Charles furnished a 25,000-kw. tandem-compound turbine generator and condenser for the Fisk Street Station of the Commonwealth Edison Company, concerning the efficiency of which unprecedented guarantees were made. This turbine set a new standard of performance in this country. In the estimation of the purchaser, this machine has a standard of reliability to be compared favorably with any other on this system. In 1924 a second turbine was furnished the Commonwealth Edison Company, of 50,000-kw. capacity, of unique design in the low-pressure range of expansion. The object of this was to secure low leaving loss. The machine has operated excellently. Both of these turbine units were the largest of their time.

In 1894 Sir Charles devoted particular attention to the application of the turbine to the propulsion of ships. Owing to the necessarily high speed of rotation, difficult problems connected with propeller efficiencies were at once encountered, and it was not until after three years of experimental investi-

gation that the famous *Turbinia* was completed. The speed performance of the *Turbinia* at the Victorian Diamond Jubilee Naval Review in 1897 attracted great attention to the system, and so rapid was the conversion of technical and public opinion in favor of the turbine for marine propulsion that by 1917 Atlantic liners with turbines of 80,000 hp. were in use in the merchant service.

Concurrently with improvement in the land turbines, corresponding advances in the marine turbine were made, so that today the coal consumption has been reduced to less than 1 lb. per shaft hp. per hour. The turbine is now universally adopted for the propulsion of warships, and all high-speed vessels in the merchant service use the same prime mover. A development invaluable to oceanic transport service was Parsons' introduction of the helical gear for reducing the relative speed of the turbine to that of the propeller, so that the turbine could run at the maximum rated speed required for high thermodynamic efficiency, while the propeller revolved at the low speed conducive to propulsive efficiency. This latter invention is almost as great in its commercial results as the invention of the turbine itself.

Sir Charles did not restrict his exceptional knowledge and insight to the solution of problems of immediate utilitarian value. He studied the behavior of different bodies, particularly carbon under high pressure, and succeeded in converting this substance into graphite. Another important investigation which he carried out in conjunction with S. S. Cook, was the determination of the cause of erosion of high-speed screw propellers. This showed that a very important part in this phenomenon was played by water hammer. The main research on this subject was dealt with in a paper read before the Institution of Naval Architects in 1929.

Sir Charles showed a great interest in optics in later years. He took over the Derby Crown Glass Works and interested himself in constructing searchlights and their mirrors, and in solving other problems in connection with light. Later with Sir Howard Grubb he formed a company to make astronomical instruments and telescopes.

Perhaps his most important contribution to engineering development was to show that by employing higher steam pressures and temperatures in marine work it was possible to obtain higher efficiencies and a proportional economy in coal consumption. This demonstration was made in 1926 and took the form of equipping the Clyde pleasure steamer, *King George V*, with boilers supplying steam at a pressure of 550 lb. per sq. in. and a temperature of 800 deg. fahr. to a 3500-hp. turbine. The experiment was in the main successful, and the correctness of the ideas has been proved by the results obtained on the most recent vessels of the Canadian Pacific Company.

Sir Charles never lost his interest in steam turbines, and reviewed the progress that has been made recently in their design in two important papers which he read before the British Association in 1929 and at the World Power Conference in Berlin last year. In these he pointed out that in addition to an increase in the steam pressure and temperature, higher economy was to be sought in the use of regenerative heating, both of the feedwater and of the steam after partial expansion. He added that these developments accompanied by the demand for larger and larger units, emphasized the value of a more economical utilization of materials used and led to the increasing employment of higher-quality steel, multiple exhausts, and important modifications in the design of the condensing equipment. These changes are reflected in the design of more recent units for which Sir Charles was responsible, one of the most noticeable of which is the 40,000-kw. set installed in the Brimsdown station of the North Metropolitan Electric Power Company.

Sir Charles was a frequent contributor to the proceedings of the leading engineering societies, by which his preeminence as a scientist and pioneer was fittingly recognized in the course of his long connection with them. He was elected a Fellow of the Royal Society as long ago as 1898, and was awarded the Rumford Medal in 1902 and the Copley Medal in 1928, being the first engineer to attain this high distinction. He became a member of the Institution of Civil Engineers in 1892, and served on its Council and that of the Institution of Mechanical Engineers. He was made an honorary member of The American Society of Mechanical Engineers in 1920, and of the Institution of Mechanical Engineers in 1925. He joined the Institution of Electrical Engineers in 1888, and was elected an honorary member in 1909, being awarded both the Franklin and the Faraday Medals of that Society. The three British institutions combined to confer the Kelvin Medal upon him in 1926. A further technical honor was the Bessemer Medal of the Iron and Steel Institute, which was awarded him in 1929. He was an honorary member of the Société des Ingénieurs Civils de France, and a member of the German Institution of Engineers. He was vice-president of the Institution of Naval Architects and president in 1913 and 1914 of the North East Coast Institution of Engineers and Shipbuilders. In 1904 he was president of Section G (Engineering) of the British Association, and in 1917 became president of the whole body. He also served as president of the Institute of Physics, the Institute of Marine Engineers, the Tyneside Unionist Association, and the Literary and Philosophical Society. The Liverpool University conferred the degree of Doctor of Science on him in 1909. He was also awarded similar honors by the Universities of Glasgow, Durham, Toronto, and Pennsylvania. He was made a C.B. in 1904, a K.C.B. in 1911, and became a member of the Order of Merit in 1927.

During the war he served on a number of committees, and was an original member of the Advisory Council of the Department of Scientific and Industrial Research and of the Fuel Research Board. Sir Charles threw himself with characteristic wholeheartedness into this work; he was tireless in suggesting new methods, in giving opportunities for experiments on a large scale, and in helping by his advice and criticism those who were carrying out investigations for the Board. He was a very agreeable as well as most efficient colleague, and though the questions before the Committee were such as to give room for wide differences of opinion, there was no friction and the proceedings were harmonious. In 1883 he married Katherine Bethell, who is a founder of the Women's Engineering Society. Their only son was killed in action in 1918. Their only daughter passed through the Engineering School at Cambridge, and served in the Training Department of the Ministry of Munitions.

Sir Charles was a generous benefactor of science, having given large amounts to the Royal Institution and to the British Association. He was one of the governors of the Dominion Students' Hall Trust, the object of which is the building of a hall of residence, London House, for Dominion, Colonial, and British students who come to the University and schools of London. In addition to a generous contribution, he gave much time to interesting the engineering profession in the scheme.

At the time of his death Sir Charles and Lady Parsons were on a pleasure trip on board the steamer *Duchess of Richmond*. After an illness of four days he died shortly before the vessel reached Kingston, Jamaica. His body was taken back to England on the first available boat. A memorial service was held in Westminster Abbey on March 3, attended by relatives, friends, and representatives of scientific and engineering societies. The American Society of Mechanical Engineers was represented. A memorial service was also held at St. Nicholas Cathedral, Newcastle-on-Tyne, the same day, and interment was at Kirkwhelpington Churchyard.

# Book Reviews and Library Notes

**THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the Engineering Foundation, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.**

**The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.**

## Hydrodynamics and Aerodynamics

HYDRO- UND AERO-DYNAMIK (Handbuch der Experimentalphysik IV, 3 Teil), edited by Ludwig Schiller. Published by Akademische Verlagsgesellschaft, Leipzig, Germany, 1930. Cloth, 6¾ × 9½, 558 pp., illus., 55 marks.

REVIEWED BY STARR TRUSCOTT[1]

THIS third part of the fourth volume of the "Handbuch" of Experimental Physics is devoted to the technical applications of hydrodynamics. The reader is carried from the motion of objects in and through water and air to devices for moving both fluids. However, even a browser would quickly discover that experiment, research, and testing have been continually foremost in the minds of the extremely competent authors who have prepared the individual sections. One might almost call this volume a research worker's manual, because of the manner in which the subjects have been presented.

Although the emphasis is on hydrodynamics, the parts played by other branches of physics, where they enter into the problems, are considered and any special methods required are discussed. The chapters on thermodynamics, or interior ballistics, which form part of the section on ballistics, are of this type. They have not the detail of a textbook on gunnery, but present the essentials with references for the student to follow if he chooses.

Most of the sections begin with an introduction which states the general problems considered and the information which is to be obtained. This is followed by a discussion of the theory or theories involved, after which methods of experiment or testing are taken up in detail. The methods of outstanding laboratories or individuals are described and the apparatus and its operation are illustrated. The form in which the results are recorded is usually given also.

The first section, comprising about 110 pages, has been prepared by Fritz Horn, of Berlin, and is devoted to a discussion of ship-model tests. It is divided into four sub-sections or chapters which, in turn, take up (1) the theoretical bases for model tests of ships, propellers, and rudders, (2) the general methods of model tests, (3) apparatus and methods of conducting tests, and (4) results.

Each of these chapters is a complete little treatise which covers its field, with references from the earlier to the latest workers. As might be expected, the influence of the more recent German work in aerodynamics is apparent in the methods and discussion.

The second section, of about 20 pages, considers the free balloon, and is by R. Emden, of Munich. This comprises a brief discussion of the construction of free balloons and of the rules or laws governing their behavior. It provides a section on elementary aerostatics, thus enabling this subject to be omitted from the following section. Although a goodly list of references is given, one is surprised to note that "Le Ballon Libre" by Do, does not appear.

The third section, of about 70 pages, is by a transplanted German, W. Klemperer, of the Goodyear-Zeppelin Corporation of Akron, and discusses the technique of airship tests. He divides this section into four sub-sections or chapters, devoted to (1) aerostatics of the airship, (2) aerodynamics of the airship, (3) the determination of the flight path, and (4) strength. As he remarks, strictly interpreted, only the first two belong to hydro- or aerodynamics. However, the reader will be glad the last two are included, for in them will be found much interesting information.

The first chapter discusses the special manner in which the airship designer and operator must consider aerostatics. An airship without power must be handled like a free balloon; under way she is a different craft, but she must always be able to resume her simpler status.

In the second chapter, the problems involved in determining the manner in which the pressures vary over the hull of an airship is taken up, as are also the old problems of resistance and propulsion and methods of measuring drag and thrust. Model experiments on the flow around an airship hull are described and the apparatus illustrated.

In the third chapter, which the author heads "Phoronomy," the various methods for determining the flight path, position, speed, course, altitude, accelerations, etc., are discussed.

The fourth chapter does not take up the strengths of the materials, as such, which are used on an airship, but discusses the methods which may be used to determine the loads or distribution of loads in the parts of an airship which is subjected to aerodynamic forces. Among other things, various types of extensometers which may be applied to girders and wires are described and illustrated. The use of water-filled models for obtaining information about the behavior of the envelopes of non-rigids is also illustrated.

The next 55 pages are occupied by a section on flight testing of airplanes, by Ludwig Hopf, of Aachen, After the introductory paragraph, which in brief but clear fashion describes the elements of the airplane, there follow four paragraphs describing the more important types of flying, or maneuvers, and showing what is happening during them. Flight testing as such is then taken

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up, and different types of maneuvers which are investigated are described, together with the instruments used and the methods followed.

Centrifugal pumps and turbines are dealt with by W. Spannhake, of Karlsruhe, in a section of about 50 pages. The theory of the subject occupies the major part of the space, giving in fact a résumé of theory and types. However, there is a brief discussion of testing laboratories and the methods of expressing the results of tests.

The subject of airscrews, by O. Flachsbart, of Göttingen, takes up about 85 pages and is divided into two sub-sections or chapters, the first being devoted to propellers and the second to windmills. Again the theory is given in résumé and is followed by discussion of the problems to be considered and the method of expressing the results. The testing of models is discussed and the equipment used is illustrated.

The manner in which the other branches of science must be drawn upon is illustrated by a small high-speed motor for driving model propellers which was developed at Göttingen in 1924. This motor has a power of 1 to $1^1/_4$ hp. with a maximum speed of 30,000 r.p.m., a diameter of only 42 mm. (1.65 in.) and a rotor length of 120 mm. (4.72 in.). Motors of these high speeds and small size make it possible to test model propellers in combination with model fuselages or airplanes at proper speeds.

The testing of full-sized propellers is also discussed, including the study of their deformation under load. Here again some pretty physical problems outside the range of hydrodynamics proper must be solved.

The chapter on windmills may surprise some American readers. Probably the title suggests to most of us the clanking windmill pumps of our Middle West. However, the windmills discussed in this chapter resemble reversed airplane propellers more than the type common here, although some years ago windmills of this type were installed to provide power for lighting airway beacons. Apparently they receive more attention in other countries, for the Central Aero Hydrodynamical Institute at Moscow has a special building for the study of windmills, and the Agricultural Institute of Oxford University is conducting extended tests on them.

In the section on air pumps, by W. Gaede, of Karlsruhe, which occupies about 50 pages, there are discussed in separate chapters the compressor, the vacuum pump, and the high-vacuum pump. The principal types of each are described and illustrated. Quite naturally, the first two chapters contain simply brief résumés. The third chapter, however, covers the evolution of the different types of high-vacuum pumps in detail and is illustrated with a relatively large number of figures.

The final section, on ballistics, by O. von Eberhard, of Essen-Bredeney, occupies about 70 pages. The author first discusses the problems of interior ballistics, such as the properties of powders and the methods of obtaining measurements of pressures and velocities in the gun, and then proceeds to the various motions of the gun and projectile. The usual problems of exterior ballistics, including methods of measuring projectile velocities and times of flight, are described and illustrated. The final paragraphs are devoted to discussions of the experimental determination of the resistance of the air, methods of sound ranging, the problem in experimental ballistics which is presented by anti-aircraft firing, and phenomena connected with the striking of projectiles.

Either as footnotes or at the end, each section has its own references or bibliography. In addition there is a very good index of subjects at the end of the book. Would that all writers of textbooks gave as complete ones! But there is also an equally complete index of names; and—something which is recommended to all who have to prepare indexes to works in which there are a number of sharply different subjects—at the bottom of each page of these two indexes there is a key giving the pages occupied by each subject.

As a general survey, this book is most useful. It is notably easy to read and requires surprisingly little in the way of preparation, either as previous specialized knowledge of the subject or as mathematics. The authors are to be congratulated for the clarity and simplicity with which they have presented their not at all easy or simple subjects, and the editors and publishers for the splendid form in which it has been issued.

## Books Received in the Library

ABNUTZUNG VON METALLEN UNTER BESONDERER BERÜCKSICHTIGUNG DER MESSFLÄCHEN VON LEHREN. By Otto Nieberding. (Berichte über betriebswissenschaftliche Arbeiten, bd. 5.) V.D.I. Verlag, Berlin, 1930. Paper, 9 × 12 in., 25 pp., illus., diagrams, tables, 6 r.m.

Extensive tests were made to ascertain the wear on various metals, and the effect of hardness and load upon wear. The investigator gives special attention to the influence of wear upon the accuracy of plug and ring gages, and to the proper methods of using them. He finds that there is no regular relation between hardness and wear, and that gages should be as light in weight as possible.

AUTOMOBILE. By Gabriel Lienhard. Nineteenth edition, 1931. Dunod, Paris, 1931. Fabrikoid, 4 × 6 in., 468 pp., diagrams, tables, 23.50 fr.

A collection of mathematical, electrical, and mechanical tables, formulas and data constantly wanted by automobile designers and builders, presented in a pocket volume at a very modest price.

AUTOMOBILE AND AIRCRAFT ENGINES. By Arthur W. Judge. Second edition. Isaac Pitman & Sons, New York, 1930. Cloth, 6 × 9 in., 845 pp., illus., diagrams, tables, $10.

After ten years, Mr. Judge presents a revised and enlarged edition of his well-known treatise upon the high-speed internal-combustion engine. The results of theoretical and experimental investigations of this engine are presented in as concise and elementary way as is feasible, with frequent references to sources for further information. This edition contains a fairly full account of the Diesel-type airplane engine.

DIE BERECHNUNG EINES FAHRZEUG-DIESEL-MOTORS. By W. Haeder. R. C. Schmidt & Co., Berlin, 1930. (Haeders Hilfsbücher für Maschinenbau.) Cloth, 5 × 8 in., 335 pp., illus., plates, diagrams, 24 r.m.

Sets forth in complete detail the steps in designing an airplane Diesel engine, showing how each calculation is made. The example selected is a six-cylinder four-cycle compressorless type, for which a series of shop drawings are given, but the book will also be useful to designers of other types.

BERICHTFOLGE DES KOHLENSTAUBAUSSCHUSSES DES REICHSKOHLENRATES. No. 22. V.D.I. Verlag, Berlin, 1930. Paper, 9 × 12 in., various paging, illus., diagrams, 150 r.m.

Six papers discussing the problem of power-plant and factory dust and flying ash. The subjects treated include: the determination of ash distribution at a distance, the English smoke-prevention law, the steam boiler as a dust separator, dust-removal methods in coal-briquetting plants and their applicability to flue gases, recent ash-separating plants, and ash formation and collection.

THE DYNAMIC UNIVERSE. By James Mackaye. Charles Scribner's Sons, New York, 1931. Cloth, 6 × 8 in., 308 pp., $3.50.

This book presents a radiational theory of the structure of matter and the cause of its change of motion. The theory is

physical, rather than mathematical or metaphysical. It aims, while accepting Einstein's equations, to give an explanation and reinterpretation of them which will be more natural. An important contribution to theoretical physics.

AN EARLY EXPERIMENT IN INDUSTRIAL ORGANIZATION; being a history of the firm of Boulton & Watt, 1775–1805. By Erich Roll. Longmans, Green & Co., London and New York, 1930. Cloth, 6 × 9 in., 320 pp., plate, $5.

An interesting study of the organization of the earliest engineering factory and of the business methods adopted in its management. The rapid development of the business is traced in detail, and its business organization and policy, wage system, relations with labor, and similar problems are discussed. The viewpoint is entirely economic.

ELEMENTARY THEORY OF TENSORS, with applications to Geometry and Mechanics. By Tracy Yerkes Thomas. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 9 in., 122 pp., $2.

This text, based on lectures given at Princeton University, expounds some of the more elementary ideas of this theory. A discussion of Euclidean geometry, kinematics, and Newtonian dynamics is included.

GRUNDLAGEN, MITTEL UND BEISPIELE ZWECKMÄSSIGER WERKSTATTMESSVERFAHREN. By Th. Damm. (Berichte über betriebswissenschaftliche Arbeiten, bd. 6.) V.D.I. Verlag, Berlin, 1931. Paper, 8 × 12 in., 31 pp., illus., 4.75 r.m.

This pamphlet aims to give a clear explanation of the principles that underlie the various measuring instruments used in machine shops, to discuss the accuracy of these instruments, and to describe proper methods of using them.

GUIDE DU TECHNICIEN POUR L'ORGANISATION DU TRAVAIL PERSONNEL. By J. Rousset. Ch. Béranger, Paris, 1930. Cloth, 6 × 10 in., 192 pp., illus., 62.50 fr.

This unusual book is a guide to the collection and utilization of information, for the benefit of engineers. The author discusses the collection and classification of notes and documents, the organization of libraries, the use of reference libraries, the writing of articles, book publishing, and a number of related topics. Much practical, sound advice is given which is not collected elsewhere.

HOW TO SET UP PRODUCTION CONTROL FOR GREATER PROFITS. Edited by Hugo Diemer. McGraw-Hill Publishing Co., New York, 1930. Bound, 6 × 9 in., 336 pp., illus., graphs, forms.

Discusses the control of production as a means to reduce inventory, expedite production, and lower costs. The book discusses basic planning methods, practical methods for controlling the production in the factory, and gives a number of case studies by officials of various firms, showing how production has been controlled in their plants.

HIGH SPEED STEEL. By Marcus A. Grossmann and Edgar C. Bain. John Wiley & Sons, New York, 1931. Cloth, 6 × 9 in., 178 pp., illus., diagrams, tables, $3.50.

The authors have endeavored to present a general view of the manufacture and properties of high-speed steel which will make clear the general laws that govern its behavior during manufacture and final preparation, and the connection between its fundamental properties and its immediately useful ones. Sound practice in melting, hammering, and rolling ingots and bars, in heating during fabrication, and in making and heat-treating finished tools is described. The fundamental physical properties, the constituent diagrams, and the microstructures arising under various conditons of manufacture and heat treatment are discussed in relation to their effect upon the mechanical properties.

## Commemorative Aeronautic Meeting

(*Continued from page 316*)

president, Curtiss Aeroplane and Motor Co., and Capt. J. H. Towers, assistant chief of the Bureau of Aeronautics, U. S. Navy, who alone survives of the first two pilots of the United States Navy, both trained by Curtiss. These addresses were abundantly illustrated with a wealth of historical photographs of the early airplanes developed by Curtiss.

The aeronautical achievements of Chance M. Vought were presented by E. E. Wilson, president, Sikorsky Aviation Corporation, who spoke appreciatively of the value and significance of this designer's work.

Admiral H. I. Cone, U. S. Navy, former head of the Guggenheim Fund for the Promotion of Aeronautics, delivered an address entitled "Daniel Guggenheim, His Encouragement of Aeronautics."

In contemplating the careers of these three men who have contributed so extensively, yet so differently, to aeronautics, one is impressed with the dramatic quality of their lives. There was unfolded in the addresses on Glenn H. Curtiss a character ready for bold adventure and of unsuspected charm. Utilizing as a pioneer must novel and empirical methods, he achieved success through instinct and ingenuity. Commenting upon the first planes built by Curtiss for the Navy, not from plans and specifications, Captain Towers said: "The wing was a lovely curve, as drawn on the wall with a few sweeps of Curtiss' arm, and it lifted the airplane; the tail surfaces to Curtiss' eye looked about right and proved to be exactly right; the thrust line was just where it happened to be after they got the engine bearers installed, and it has never changed." And finally: "Glenn Curtiss was a remarkable man . . . . Mathematical formulas rather confounded him, and he did not seem to need them. He never claimed to be an engineer." Undoubtedly, however, he was a genius.

Glenn Curtiss was a successful pilot to whom many honors and trophies were awarded. The younger Chance Vought, a pilot also, learned to fly under the tutelage of the Wright brothers in 1910 and qualified as a pilot in 1911. Like Curtiss his skill as a pilot made him keenly sensitive to the reactions of the pilots who flew his ships, and like Curtiss he had an intuitive ability in design which might be classed as genius. His manufacturing career commenced early, and was financially as well as technologically successful.

Daniel Guggenheim was of a different type. Neither pilot nor designer, his interest in aviation, aroused by his son's experience during the war, was first crystallized in his gift to New York University of $500,000 for its department of aeronautics. Subsequently he established the Daniel Guggenheim Fund for Aeronautics, amounting to $2,800,000. Through this fund, aerodynamic laboratories and wind tunnels were built in various engineering schools throughout the country, and numerous researches in aeronautics and safety in flying were aided. In addition to New York University, 8 colleges were aided, a sum of about a million and a half being so expended. The notable Safe Aircraft Competition with a prize of $100,000 brought forth the Curtiss *Tanager*. Other activities included the establishment of the Airship Institute, grants of funds to aeronautical societies in this country and abroad, the work of the Committee on Elementary and Secondary Aeronautical Education, the publication of numerous bulletins and pamphlets, installation of the model weather reporting service, a roof-marking campaign, a study of fog flying, and an unrivaled library of aeronautics established in the Library of Congress. The encouragement and assistance of this distinguished patron of aviation has been a powerful influence in the rational development of aeronautic science and transportation in this country.

# Synopses of A.S.M.E. Transactions Papers

**THE papers abstracted on this and following pages appear in the current issues of the Hydraulic, Iron and Steel, Materials Handling, and Printing Industries sections of A.S.M.E. Transactions. These sections have been sent to all who registered in the similarly named Divisions. Other sections are in the course of preparation and will be announced, when completed, in later issues of "Mechanical Engineering."**

## HYDRAULIC PAPERS

THE FLOW OF FLUIDS THROUGH ORIFICES IN SIX-INCH PIPES. By S. R. Beitler and Paul Bucher. [Paper No. HYD-52-7a]

In this paper the authors tell of work done in the calibration of orifices and a nozzle in a six-inch pipe line, using water and steam as the fluids to be metered. Two series of orifices were tested. One series included concentric orifices with from 15 per cent to 84 per cent diameter ratio. The second series included concentric orifices with from 64 per cent to 87 per cent diameter ratio. The nozzle tested was a one-flow type with 58 per cent diameter ratio.

QUANTITY-RATE FLUID METERS. By Ed S. Smith, Jr. [Paper No. HYD-52-7b]

In this paper the venturi tube and square-edged orifice are placed upon a common basis and simple graphical methods of use are shown. This common basis is rigorously derived from the laws of flow similarity and dimensional homogeneity in the body of the paper.

The dimensionally correct "hydraulic" formula is used as the common basis in metering fluids ranging from highly viscous oils to expansible fluids (gases) with both types of meters, which does not involve gravitation $g$ in any way. This formula is derived for the venturi tube (or nozzle) with a frictionless liquid, in which case the coefficient $C$ and the expansion factor $Y$ are both unity.

For liquid meters, the coefficient "$C$" depends only on the Reynolds number, included when the coefficient is substantially flat, which it generally is, except for unusually small meters or for those measuring viscous fluids such as heavy oils or hydrogen gas. For a liquid, the coefficient $C$ does not depend at all upon the acoustic ratio $x/n$, since there are practically no expansibility effects involved. This is also true for a gas when the differential is relatively low. Also where the differential is relatively high, exactly the same coefficient would be used for a gas as for a liquid having the same Reynolds number, or as though the gas were a liquid having the same density and viscosity. The net expansion factor $Y$ corrects for all of the expansion effect which exists due to the gaseous nature of the fluid.

The paper also presents material on factors which cause departure from the theoretical flow conditions, illustrations of the flow with venturi tubes and orifices, viscosity, friction loss, and flow in pipes, as well as other related matter.

SIMILARITY: LIMITATIONS IN ITS APPLICATION TO FLUID FLOW. By J. M. Spitzglass. [Paper No. HYD-52-7c]

A brief résumé of the development of the art for the purpose of bringing about a better understanding of the effects of hydraulic similarity as related to the geometrical similarity of the various devices. Geometrical similarity is of great importance, and devices which are geometrically similar will make the operation more uniform. Geometrical similarity is a matter of construction. Hydraulic similarity is a matter of experiment. Large sizes may or may not show the same results as the smaller ones.

THE KAPLAN ADJUSTABLE-BLADE TURBINE. By B. E. Smith. [Paper No. HYD-52-8]

In this paper the author gives details of construction of the Kaplan adjustable-blade hydraulic turbine, and tells of the advantages obtained by adjusting the blades and the wicket gates simultaneously. This turbine differs from the ordinary wicket-gate turbine in the shape of the top plate and the construction of the runner and shaft. The top plate is shaped so as to form a transition space free from vanes between the wicket gates and the runner, in which the direction of flow of the water is changed from radial to axial. The runner hub carries the movable blades, and the operating connections for moving the blades are inside the single-piece hub casting.

## IRON AND STEEL PAPERS

PROTECTION OF MOVABLE MATERIAL-HANDLING BRIDGES AGAINST WINDSTORM HAZARDS. By C. O. Burton. [Paper No. IS-52-4]

Present-day speeds and efficiency in handling enormous tonnages of bulk materials, such as coal, coke, ore, crushed stone, etc., have been made possible only by the development of modern types of material-handling bridges. Such bridge structures now seem to be absolutely essential in the operation of coal docks, blast furnaces, and steel plants for unloading, stocking, and reloading the bulky raw materials of industry. Since they are so indispensable, it follows that their protection against all possible causes of loss or damage becomes of vital importance. By reason of their great length and height, such bridges present large wind-resistive areas, making them particularly susceptible to windstorm damage. This paper discusses some of the factors of design and construction that affect the safety of these structures, and describes and discusses the special equipment designed to increase the operating safety of bridges. The author tells of the development of material-handling bridges, and their constructional elements, so that the more specific features of bridge protection against storm damage may be better understood.

MANUFACTURE OF LARGE WELDLESS FORGED-STEEL PRESSURE VESSELS. By John L. Cox. [Paper No. IS-52-5]

This paper describes in detail the various steps taken in the manufacture of large weldless forged-steel cylinders for high-pressure boiler drums and for various uses in the oil-refining and chemical industries. It covers the melting, casting, and heating of the ingot; cutting off, piercing, and expanding the billet; forging, treating, and machining the cylinder; and illustrates a number of ways in which the ends of the cylinder can be closed.

CONTINUOUS REHEATING FURNACES FOR ROLLING MILLS. By A. L. Culbertson. [Paper No. IS-52-6]

The subject of this paper is much broader than could be expected from a casual glance, due to the many types of furnaces used for the various rolling-mill operations. The subject-matter is confined to those furnaces used for reheating purposes necessary for serving rolling and piercing mills. Even this reduced field leaves it an extremely broad one when considering the types of furnaces required for the different operations.

The author discusses the various classes, using only broad subdivisions of each, and with this in mind a chart is given to show this classification, in order to permit of some common points of comparison, both as to design and operation.

GERMAN AND AMERICAN STEEL-PLANT PRACTICE. By F. L. Estep. [Paper No. IS-52-7]

The United States leads the world in the production of steel, and Germany has again become second. The greater percentage of the total amount of steel made in the United States is used domestically, whereas, on the other hand, a very large percentage made in Germany is exported. This in itself has had a certain influence upon the processes developed, methods pursued in the two countries, and the supply and cost of raw materials. Another factor which has affected the methods and the equipment used is the quantity and quality of labor available and the wages which must be paid.

In Germany today the greater percentage of ore used comes from foreign countries, while in the United States the great bulk of the ore is mined at home. Coal is plentiful and of good quality in Germany, but its price for metallurgical purposes is higher today than the coals commonly used in the United States for the same purpose. This paper shows to some extent where the processes differ.

CLEANING, DISTRIBUTION, AND USES OF BLAST-FURNACE GAS. By William A. Haven and C. B. Thorne. [Paper No. IS-52-8]

In this paper the authors discuss blast-furnace operation and show the relationship between blast-furnace operation and the amount and quality of blast-furnace gas produced. A comparison is given between methods and costs of gas cleaning, the distributive equipment and cost of distribution, application for various purposes, and the profit that can be expected from blast-furnace gas as a by-product.

THE APPLICATION OF METALLIC RECUPERATORS TO INDUSTRIAL FURNACES. By G. D. Mantle. [Paper No. IS-52-9]

Increasing cost of fuels and the growing pressure of competition make apparent the necessity of heat salvage in metallurgical furnaces. The paper asserts that there are few industrial furnaces that cannot be made 20 per cent more efficient by the installation of heat recuperators. A properly applied recuperator may result in an increased efficiency of 50 per cent. The actual value of heat salvaged from the waste gases by recuperation or regeneration is little appreciated by the average engineer.

DESIGN AND CONSTRUCTION OF HOT SAWS FOR CUTTING HEAVY SECTIONS. By A. B. Pearson. [Paper No. IS-52-10]

Sawing is an ancient art, and it may be said without fear of contradiction that its origin dates from primeval times. A stone or a shell with a ragged edge may have served as the implement, and the pressure or feed, as well as the speed, were then, as now, very important factors in the undertaking. Other methods of cutting have been found, but the abrasion process is still the one that is most generally employed for cutting heavy material to length. In the use of this process, as in sawing, the cutting tool is generally harder than the material being sawed. The author describes saws for cutting hot and cold metals, and gives results of tests on a variety of saws.

FORCES ACTING ON ROLL-NECK BEARINGS. Report of the Special Research Committee on Heavy-Duty Anti-Friction Bearings. By W. Trinks, Chairman, and J. H. Hitchcock, Research Associate. [Paper No. IS-52-11]

Unless flaws exist in some of the balls of bearings, final failure is usually caused by fatigue due to many applications of the load. Consequently the average load should be known accurately and the maximum load approximately.

There are now five methods for determining the bearing loads on roll-neck bearings. The first includes use of Brinell balls and plates and is suitable for determination of maximum loads only. The hydraulic cylinder, second, and the strain gage, third, are suitable principally for determination of average loads. The fourth and fifth methods, of comparatively recent development, are the telemeter, or carbon pile, and the electrical condenser. These latter two methods are practically free from inertia effects and may be used to determine either maximum or average loads.

The efforts of the committee have been directed largely toward the collection, coordination, and analysis of existing data. An attempt has also been made to evaluate all existing data.

## MATERIALS HANDLING PAPERS

DESIGNING FOR SAFETY IN MATERIALS HANDLING. By R. H. Hucke. [Paper No. MH-52-5]

The author covers the special handling of large cases for shipment. The equipment designed to meet the operating conditions is described and also the features of safety and speed in handling materials. Every conveyor before installation must pass the inspection of the works engineer, and after installation the system is checked over to see that proper guards and switches are supplied.

RECENT DEVELOPMENTS IN MATERIAL HANDLING AT THE WESTERN ELECTRIC COMPANY'S MERCHANDISE BUILDINGS AT KEARNY, N. J. By C. K. Pevear. [Paper No. MH-52-6]

A description is given of the Western Electric Company's merchandise buildings at Kearny, N. J., their purpose, and the methods used in material handling in these buildings. A thorough study was made of the purpose of these buildings, the type of the material to be handled, and the possible future changes that might be made in the amount of work to be done and the dimension of units handled. Then the warehouse activities were laid out, and a building was designed to enclose them. Approaching the problem in this manner provided unusual design opportunities not generally met, as in most cases equipment has to be fitted into an existing building.

WHAT DOES THE MATERIALS-HANDLING EQUIPMENT MANUFACTURER NEED TO KNOW TO MAKE A SUCCESSFUL INSTALLATION? By N. H. Preble. [Paper No. MH-52-7]

The answer to the problem of making a successful installation of materials-handling equipment is not always simple, and, due to varying conditions, is not always the same. In general, however, the following conditions must be examined: (1) Purpose of proposed handling installation. (2) Nature, weight, size, etc., of material or articles to be handled. (3) Capacity required. (4) The path which the material must follow. (5) Details of building or space within which the equipment is to be used. (6) General information as to power available; unusual conditions of temperature, moisture, etc.; erection conditions; and the like. The paper outlines in detail these various items, with a view to assisting the buyer.

MATERIALS HANDLING IN THE PLANT OF THE GOODYEAR TIRE AND RUBBER COMPANY. By C. C. Stuber. [Paper No. MH-52-8]

In the plant described, 964 people are kept busy transporting an average of 1,863,269 lb. of material in process of manufacture over a floor space of 6,443,419 sq. ft. by the use of 17,000 electric power trucks, industrial hand trucks, and platform skids. This equipment would make a train 19 miles long. There are 81 elevators and 29,654 ft. of conveyors. The industrial trucks are under centralized control.

SYMPOSIUM ON THE ECONOMICS OF DELIVERY SERVICE.

The following papers are included: Economic Aspects of Gasoline-Operated Commercial Vehicles, by R. E. Plimpton; Economics of the Electric Truck in Delivery Service, by H. L. Forman; Economics of the Electric Street Truck, by L. A. De More; Economics of Highway Trailers and Semi-Trailers, by W. G. Retzlaff. [Paper No. MH-52-9]

These papers cover gasoline and electric vehicles and discuss the application of motor trucks operated over public highways to the service of industrial plants. The economic place of the truck is approached from two angles:

1 Its function in promoting (*a*) the flow of raw and semi-finished material into the factory or plant; (*b*) the movement between plants under a single management or from any of these plants to the warehouses or branches; and (*c*) the final physical distribution to customers or consumers.

2 The ownership of the trucks engaged in the productive process as (*a*) by the industrial plant itself or (*b*) by outside specialists working as contract or common carriers.

The several authors also take up the growth of motor express and freight companies, especially emphasizing their relation to the industrial plants, particularly of the type that is manufacturing goods that are shipped in small lots and sold through outlets dealing directly with the general public.

PLACING WET CONCRETE WITH BELT CONVEYORS. By E. L. Benson. [Paper No. MH-52-10]

In this paper the author tells of various construction jobs where belt conveyors have been used successfully for placing the wet concrete. Figures are given to show the economies of belt-conveyor use for such purposes, and the particular types that best meet specific conditions. There are a number of things that must be given consideration in the design of conveyors for handling wet concrete. The author tells how special conditions are met.

MATERIAL HANDLING IN PRODUCTION OF PORK PRODUCTS. By A. W. DeVout. [Paper No. MH-52-11]

This paper describes the various operations through which hogs pass from the buying pens in the stockyards until the various products are dressed, boxed, and placed in refrigerator cars ready for shipment. Handling equipment plays an important part in speeding up the operations, lowering costs, and doing away with heavy manual handling.

HIDDEN COSTS IN MATERIALS HANDLING. By J. I. McCormick. [Paper No. MH-52-12]

A large variety of material-handling equipment and methods are used at the East Pittsburgh plant of the Westinghouse Electric and Manufacturing Company. The author tells how material is handled in different departments and the type of handling equipment found best suited to the requirements. He discusses various material-

handling problems in a general way and tells of methods that are essential to reduce handling to a minimum.

CONVEYOR HANDLING METHODS OF THE CHICAGO "DAILY NEWS." By Matthew W. Potts. [Paper No. MH-52-13]

In this paper the author describes the conveyor handling system as installed in the plant of the Chicago *Daily News*. Continuous conveyors are used to handle rolls of paper from railroad cars and barges to the storage room, and then to the reel room. Conveyors are also used for handling stereotype plates to the press room, bundles of papers from the presses to the truck platforms, and mats from the makeup room to the stereotype room.

HANDLING MATERIALS IN AN AUTOMATIC FRAME PLANT. By A. W. Redlin. [Paper No. MH-52-14]

In this paper the author describes the methods and equipment used in handling materials in the automobile-frame plant of the A. O. Smith Corporation. Many types of conveyors are used in this automatic plant, and inventive skill has brought out a large variety of materials-handling devices.

## PRINTING INDUSTRIES PAPERS

THE PRINTING ENGINEER AND PRINTING PROFITS. By W. L. Churchill. [Paper No. PI-52-7]

While the average earnings of printing and publishing plants are above the average of manufacturing industries, fully one-third of the businesses reporting showed a deficit averaging 9.26 per cent of their sales. Here is a highly technical industry manned by those who have had to devote years to specialized training and that operates with a high average of loss and with earnings insufficient to perpetuate the business. The engineer should be trained to think in terms of profits. Profits do not necessarily follow savings. Proper management requires that the engineering mind discover and eliminate the factors that prevent or destroy profits.

SOME PROBLEMS IN PRINTING STANDARDIZATION. By Fred S. English. [Paper No. PI-52-8]

The lack of standardization of certain factors which enter into the design and use of cylinder printing presses is discussed in a general manner, particularly relative to the standardization of plates and bases, diameters of cylinders, depth of impression surface below cylinder bearers, height of bed bearers, sheets, forms, and names of parts.

DESIGN OF THE NEW HARRIS AUTOMATIC TWO-COLOR FLAT-BED PRESS. By Alfred S. Harris. [Paper No. PI-52-9]

A recent design of two presses, one a single-color and the other a two-color press, includes the standardization of parts and units to such an extent that 72 per cent of these parts are common to both presses. A few of the points described in the design are those contributing to rigidity of frame, impressional strength, uniformity of bed travel during the printing stroke, evenness of ink distribution, and accuracy of register. Accessibility to its adjustments and convenience for make-ready also received attention.

SIZES AND TOLERANCES FOR METAL FITS. By C. R. Reiman. [Paper No. PI-52-10]

This paper discusses comparisons of metal fits. The matter of working fits being left in many plants largely to the opinion and ability of the workman, the need of standardization in consequence asserts itself as organizations are entitled to records of these matters. The comparisons of the practice of other standards and the analysis that influences the conclusions are given in a simple way. Simplification for better understanding is aimed at, and the need for a standard common practice throughout the industry is recognized. Controlling influences are considered, and various features for which advantages are claimed are stressed. The use of the basic size to under hole system, and the basic shaft are discussed. Different kinds of fits are compared, and the reasons for differentiating between straight shafts and turned studs are given.

FORCES IN CONNECTION WITH THE RECIPROCATING BEDS OF FLAT-BED CYLINDER PRINTING PRESSES. By B. D. Stevens and H. E. Golber. [Paper No. PI-52-11]

This article deals with printing-press beds, their mechanisms and forces. The mechanisms of some well-known presses are described sufficiently to show that the dynamic problems are identical for all. The forces are examined as to their effect upon the motor, the machine, and the building. Reference is made to certain methods which have been tried for reducing or counterbalancing them, and some criticisms and suggestions are made.

**NOTE: Those who have not registered in the A.S.M.E. Hydraulic, Iron and Steel, Materials Handling, and Printing Industries Divisions whose papers are abstracted on this and the previous pages, and who desire copies of any of these papers, may obtain them by using the form given below.**

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### AIR COMPRESSORS

**Manufacture.** The Works of Messrs. Reavell and Company, Limited. Engineering, vol. 131, no. 3391, Jan. 9, 1931, pp. 33–36, 13 figs. partly on p. 48 and supp. plates. Developments which have taken place in Ranelagh Works, Ipswich, since 1913; layout, equipment and manufacturing methods of plant specializing in manufacture of compressed-air plants, with brief descriptions of some of machines manufactured.

### AIR CONDITIONING

**Equipment.** Power and Heat Requirements for Air Conditioning. Power Plant Eng., vol. 35, no. 1, Jan. 1, 1931, pp. 73–75, 2 figs. Pumps, fans, filters, and heaters require plant services in laundering air; diagram of typical air conditioning unit; water used to humidify; resistance curves to air-flow of three typical air filters.

**Procedure.** Neuzeitliche Luftveredelung durch Wasservernebelung mittels Kreiselkraftduesen (Modern Air Conditioning Through Evaporation of Water by Means of Centrifugal Nozzles), F. Mueller, V.D.I. Zeit., vol. 75, no. 4, Jan. 24, 1931, pp. 105–106, 4 figs. Value of oxygen and water-vapor content of air; adsorption of oxygen by water spray; increasing oxygen solubility and purification of air; application of atomization of water for industrial and medical purposes.

### AIRPLANE ENGINES

**Deeble Duplex.** Deeble Duplex Engine, N. French. Aero Digest, vol. 18, no. 1, Jan. 18, 1931, p. 76, 3 figs. Operating principles and design of six-cylinder inverted in-line air-cooled engine calculated to deliver 300 hp. at 2000 r.p.m.; bore 4.5 in. and stroke 5.0 in.; application of double-acting principle by employing double piston; engine weight complete 550 lb.

**Diesel, Fuels for.** Aircraft Diesel Engine Fuels, W. H. Graves. Am. Petroleum Inst.—Proc., vol. 11, no. 75 (sec. 3), Dec. 31, 1930, pp. 53–57 and (discussion) 57, 5 figs. Fuel system of Packard Diesel aircraft engine and how it differs from Otto cycle or gasoline engine; properties of fuel oil which are essential and non-essential to engine; relation of gravity, viscosity, flash point, autogenous ignition temperature, pour point, distillation, sulphur, and ash to proper operation of engine.

### AIRPLANES

**Airfoils.** An Extended Theory of Thin Airfoils and Its Application to the Biplane Problem, C. B. Millikan. Nat. Advisory Committee for Aeronautics—Report, no. 362, 1930, 33 pp., 16 figs. New treatment, due essentially to von Kármán, of problem of thin airfoil; standard formulas for angle of zero lift and zero moment, and analysis of disturbing or interference velocities; interference effects for 3-dimensional biplane, which permit characteristics of individual wings of arbitrary biplane without sweepback or dihedral to be calculated.

**Burnelli Transport.** Investigation of the Burnelli Type Airplane, F. Wertenson. Aero Digest, vol. 18, no. 1, Jan. 1931, pp. 57, 128 and 130, 3 figs. Performance tests and comparative investigation of Burnelli U-20 transport utilizing all-wing principle construction; graphs show lift and resistance coefficients and lift coefficient over attack angle.

**Design.** The Paris Aero Show, 1930, H. J. Pollard. Flight, vol. 23, no. 5, Jan. 30, 1931, (supp.) pp. 96a–96d, 10 figs. Review of new features of principal makes, with particular regard to various types of joints used in metal construction, and their relative advantages.

**Seaplanes.** See SEAPLANES.

### ALLOY STEELS

**German.** German Special Steels, E. Pohl. Eng. Progress, vol. 12, no. 1, Jan. 1931, pp. 1–6, 8 figs. Physical properties and composition of open-air corrosion-resisting and stainless steels; special steels for bridge and building construction, boilers, chemical industrial apparatus, and for manufacture of rolling stock; special mild-steel ship chains; special magnetic steels for electrical industry; high-speed steel and high-grade alloys for machine-tool cutters.

### ALLOYS

**Aluminum.** See ALUMINUM ALLOYS.

**Bearing Metals.** See BEARING METALS.

### ALUMINUM ALLOYS

**Heat Expansion.** Untersuchung der Waermeausdehnung von Aluminium-Leichtlegerungen (Study of Thermal Expansion of Aluminum Light Alloys), H. Siegierschmidt. Zeit. fuer Metallkunde, vol. 23, no. 1, Jan. 1931, pp. 26–30, 7 figs. Based on results of exact, frequently repeated expansion measurements, thermal expansion coefficients are determined for duralumin, lautal, and a copper-aluminum with 5 per cent copper, as well as of pure and commercial aluminum by way of comparison; special emphasis was laid on determination of influence of time.

**Heat Treatment.** The Heat Treatment of Aluminum Alloys in the Electric Furnace. Metal Industry (Lond.), vol. 38, no. 3, Jan. 16, 1931, pp. 81–82, 6 figs. Two typical alloys, 17S and 51S, are considered with view to illustrating function of heat treatment; artificial aging.

### ASSEMBLING MACHINES

**Design.** Design of High-speed Assembling Machine, C. O. Herb. Machy. (N. Y.), vol. 37, no. 5, Jan. 1931, pp. 347–349, 4 figs. Constructional features of machine that assembles electrical resistor units at rate of 250 per min. at plant of Allen-Bradley Co., Milwaukee, Wis.

### AUTOMOBILE ENGINES

**Design.** Linear Inertia Force of Connecting Rod Resolved Into Two Components, M. W. Davidson, Automotive Industries, vol. 63, no. 14, Oct. 4, 1930, pp. 479–481, 4 figs. Dynamic effect of inertia of connecting-rod on bearing and guide pressures, crank and frame torques, and on vibration in reciprocating machinery.

**Diesel.** See DIESEL ENGINES, Automotive.

**Franklin.** Development of the Franklin Direct Air-Cooled Engine, E. S. Marks and C. T. Doman. Soc. Automotive Engrs.—Jl., vol. 28, no. 2, Feb. 1931, pp. 177–183, 14 figs. Relation of waste heat to cooling-fin areas and cooling-blast velocities is shown for cylinders up to $3^1/_2$ in. bore; method to maintain at less than 0.003 in. any variation in valve clearance; present engine of $3^1/_2$ by $4^1/_4$ in. bore and stroke develops 87 hp. at 3000 r.p.m.

### AUTOMOBILES

**Ball Bearings for.** Determination des dimensions des roulements à billes pour automobiles (Determination of Dimensions of Ball Bearings for Automobiles), C. Dantin. Génie Civil, vol. 98, no. 2, Jan. 10, 1931, pp. 39–41, 3 figs. Calculation of ball-bearing dimensions for gear box, differential and front wheels based on analysis of forces acting on these elements under various conditions, and on experience.

**Clutches.** New Automatic Clutch Makes Its Initial Bow at Gotham Show. Automotive Industries, vol. 64, no. 2, Jan. 10, 1931, p. 55, 1 fig. Sketch illustrates design of Powerflo clutch developed by automatic Drive & Transmission Co., Inc., of Gloucester, N. J.; at idling speeds clutch is disengaged and as engine is speeded up, clutch disks engage.

**Conveyor Assembly.** Conveyors for Efficient Operation, K. B. Knapp. Power Plant Eng., vol. 35, no. 2, Jan. 15, 1931, p. 168, 1 fig. Design and operating characteristics of conveyor system which brings parts to assembly point in Buick's transmission-assembly and machining plant.

**Skidding.** Factors Affecting the Motion of a Four-Wheeled Vehicle With Locked Wheels, J. Bradley and S. A. Wood. Automobile Engr., vol. 21, no. 276, Jan. 1931, pp. 34–38, 11 figs. Program of Road Research at National Physical Laboratory on Behalf of Ministry of Transport; skidding characteristics as affected by weight distribution on wheels; height of center of gravity; moment of inertia about vertical axis through center of gravity.

**Springs and Suspension.** Der Einfluss der Daempfung auf das Verhalten eines Wagens auf Unebener Bahn (Effect of Damping on Action of Car on Rough Roads), J. Geiger. Automobiltechnische Zeit., vol. 34, no. 3, Jan. 31, 1931, pp. 56–59, 7 figs. Mathematical analysis of damping

effect in its relation to mass and acceleration; graphs illustrate relation between amplitude, frequency of forced vibration and natural frequency of mass.

Unsprung Weight Is Greatly Reduced With Stub-Axle Type of Suspension, P. M. Heldt. Automotive Industries, vol. 63, no. 14, Oct. 4, 1930, pp. 472–476, 8 figs. Suspension is illustrated by examples of European designs, Roehr, Voran, Sizaire, Bucciali; diagram showing relation of parts of mechanism when stub axle is supported by leaf springs of unequal length.

Watson Rubber Interleaves. Automotive Industries, vol. 64, no. 4, Jan. 24, 1931, pp. 129–130, 2 figs. Design and functioning of innovation to eliminate unpleasant small amplitude vibration introduced by John Warren Watson Co., Philadelphia.

**Transmissions.** Gear-Changing Indicator for Motor Vehicles. Engineering, vol. 131, no. 3391, Jan. 9, 1931, p. 57. Device, which enables quite inexpert driver to make perfect change; takes form of stroboscopic indicator, showing when wheels to be engaged are running at same peripheral speed; developed by A. J. Heronimos.

# B

### BALANCING

**Vibration Problems.** Unusual Balancing Problems, P. Davey. Machy. (N. Y.), vol. 37, no. 5, Jan. 1931, pp. 325–328, 5 figs. Methods of analyzing and eliminating excessive vibrations due to mechanical and electric unbalance and other causes by means of Davey portable balancing equipment.

### BALANCING MACHINES

**Types.** Obviating Mechanical Troubles by Balancing of Parts, W. I. Senger. Machine Design, vol. 3, no. 1, Jan. 1931, pp. 29–32 and 78, 8 figs. Principles of balancing in cylinders and crankshafts and design of balancing machine; chart showing centrifugal force exerted by unbalance at various speeds.

The Balancing of Machinery, C. N. Fletcher. Mech. World, vol. 89, nos. 2297 and 2299, Jan. 9, 1931, pp. 36–37 and Jan. 23, pp. 82–85, 13 figs. Jan. 9: Schenk "Lawaczeck Heymann" balancing machine. Jan. 23: Schenk "Production" balancing machines; Olsen Lundgren production dynamic balancing machine.

### BEARING METALS

**Cadmium.** Cadmium Bearing Metal, A. J. Occleshaw. Commonwealth Engr., vol. 18, no. 5, Dec. 1930, pp. 177–179. Results of water-cooled, uncooled, and service tests of cadmium alloy bearings; physical data relating to freezing range, Brinell hardness, casting properties, and microstructure.

### BELT DRIVE

**Short-Center.** Using a Pivoted Motor for Short Center Drives, F. W. Parkhurst. Indus. Transmission and Conveying, vol. 38, no. 1, Jan. 1931, pp. 8–10, 12 and 16, 5 figs. Transmission factors which affect drive; Rockwood pivoted motor drive; advantages of pivoted motor drive; method of maintenance tension; cost comparisons.

### BLAST FURNACES

**Belgium.** Modern Blast Furnaces in Belgium, M. Derclaye. Iron and Coal Trades Rev., vol. 122, no. 3280, Jan. 9, 1931, pp. 37–39, 5 figs. In reconstruction work, advantage was taken of experience in many countries; development in design has followed recent American practice as to general lines and some details; developments at Ougrée-Marihaye; hearth casing; lintel; tuyère jacket or belt; bosh and stack bindings; sundry details. Abstract translated from La Technique des Travaux, date not specified.

**Design.** Economical Aspects of the 1000-Ton Blast Furnace, H. A. Brassert. Blast Furnace and Steel Plant, vol. 19, no. 1, Jan. 1931, pp. 89–91 and 98, 2 figs. Design and operation of blast furnaces with particular regard to developments in Germany; data on temperatures and principal dimensions; Eichenberg process for prevention of flue dust; auxiliary equipment, stoves, gas washing, etc.

**Practice.** A Statistical Analysis of Blast-furnace Data, R. S. McCaffery and R. G. Stephenson. Am. Inst. Min. and Met. Engrs.—Tech. Pub., no. 384, for mtg. Feb. 1931, 13 pp., 6 figs. Analysis undertaken to determine some of the relations which exist between variables involved in furnace operation, and particularly to show effect of variation of slag composition on coke consumption, daily tonnage of pig iron, and sulphur elimination; results of preliminary study of blast-furnace daily operating reports, to indicate suitability of method of attack and something of results that may be expected from extended statistical examination of such data. Bibliography.

Trends in Blast-Furnace Development, T. L. Joseph. Rolling Mill Jl., vol. 5, no. 1, Jan. 1931, pp. 11–14, 1 fig. Developments in ore supply, blast-furnace design, and utilization of blast-furnace gas, described by Supervising Engineer, N. Central Experiment Station, U. S. Bureau of Mines.

### BOILER FEEDWATER

**Treatment.** Versuche und Erfahrungen mit der Kesselwasser-Rueckfuehrung (Tests and Experiences With Boiler Water Return System), Feige and Weiss. Archiv fuer Waermewirtschaft, vol. 12, no. 1, Jan. 1931, pp. 16–18, 4 figs. Results of recirculating tests on lime-soda treatment plant connected to 1000-sq. m. vertical-tube boiler; experiences with sludge return system with regard to salt enrichment of sulphates, chloride, and maintenance of sodium content; losses with periodical sludging.

### BOILERS

**Corrosion.** Der Einfluss rost- und steinfreier Waermeuebertragungsflaechen auf den Brennstoffverbrauch bei Niederdruckdampfkesseln (Effect of Transfer Surfaces Free of Rust and Scale Upon Fuel Consumption of Low-Pressure Boilers), H. Balcke. Gesundheits-Ingenieur, vol. 53, nos. 50 and 51, Dec. 13, 1930, pp. 802–809, and Dec. 20, pp. 822–824, 11 figs. Tests made on behalf of Groeck-Wasserveredlung, G.m.b.H. for determining economy of Company's scale-removal process; Strebel boiler of 40 sq. m. heating surface was used; by use of patented process fuel consumption was reduced by 18.3 per cent and heating surface load raised from 11 to 13 kg. per sq. m.

**Furnaces—Design.** Submerged Grinder Rolls Prevent Overheating, R. A. Foresman. Power, vol. 73, no. 3, Jan. 20, 1931, pp. 111–112, 1 fig. Historical review of development and use of clinker grinder which led to new design of stoker and clinker-grinder pit by Westinghouse; large over-feed section at bottom of stoker, solid brick or refractory front wall and submersion of clinker grinder rolls under water; advantages of design features.

**Furnaces, Turbine.** Mechanically-Fired Turbine Furnace. Engineering, vol. 131, no. 3392, Jan. 16, 1931, p. 95, 2 figs. Example of successful combination of two well-known boiler appliances in new arrangement of turbine furnace with sprinkler-type stoker; characteristic features of hand-fired turbine furnace have been retained; provision is made of secondary grate, without troughs, lying between furnace proper and bridge; extension provides combustion space, since supply of secondary air can be admitted through bar spaces; it also forms grate on to which incandescent fuel can be pushed and kept burning, while clinker is being removed from main grate.

**Lancashire.** A Super-Lancashire Boiler. World Power, vol. 15, no. 85, Jan. 1931, pp. 70–71, 1 fig. Notes on boiler developed and tested at plant of manufacturer at Dukinfield, England; complete unit comprises boiler 20 ft. long by 8 ft. 6 in. diam., superheater, air heaters, induced-draft fan direct-coupled to small high-speed engine, and forced-draft fan direct-coupled to 5-b.hp. motor; test data; overall thermal efficiency 83.31 per cent; longitudinal and end sectional views.

**Manufacture—Welding.** Welding Practice on the Illinois Central System. Boiler Maker, vol. 31, no. 1, Jan. 1931, pp. 9–12, 10 figs. Equipment and operation of fusion welding by electric-arc process; methods for welding side sheets and door sheets, and removing back ends and firebox sheets; methods of welding flues, staybolt hole cracks and mud-ring corners.

**Pulverized-Coal.** Powdered Fuel for Lancashire Boilers. Engineer, vol. 151, no. 3915, Jan. 1931, pp. 110–111, 6 figs. At Grimethorpe Coal Mine of Carlton Main Co., near Doncaster, there have been in service for some time four Lancashire boilers fired with powdered coal, which have proved entirely satisfactory; results of tests.

Powdered Fuel, With Special Reference to Lancashire Boilers, H. J. Hill. Instn. Min. Engrs.—Trans., vol. 80, pt. 3, Dec. 1930, pp. 158–166 and (discussion) 166–177, 7 figs. on supp. plates, following p. 210. Considerations that arise in design and operation of powdered-fuel plants; desirability of fine pulverization; effect of moisture in coal; provision for ash disposal, when ash content is high; length and behavior of flame produced by burners; difficulties in applying pulverized fuel to Lancashire boilers; test data on two Lancashire boilers 30 ft. by 8 ft. in diam.; cost of installation and operation.

**Tubes—Beading.** Einwalzen und Einpressen von Kessel- und Ueberhitzerrohren bei Verwendung verschiedener Werkstoffe (Beading and Inserting of Boiler and Superheater Tubes of Different Construction Materials). A. Thum and R. Jantscha. Archiv. fuer Waermewirtschaft, vol. 11, no. 12, Dec. 1930, pp. 397–401, 13 figs. Results of tests on influence of degree of beading and properties of tube and flange material on adhesive strength of cylindrical joints; investigation of dependence of adhesive force and density on method of rolling and on temperature; new method of inserting tubes with uniformly distributed measurable internal pressure and comparison with older methods.

**Waste-Heat.** Tests Reveal Efficiency of Clarkson Waste-Heat Boiler, T. Clarkson. Power, vol. 73, no. 4, Jan. 27, 1931, p. 156, 1 fig. Development of Clarkson boiler, with particular reference to installation on Diesel engines and test results; cross-sectional diagram of boiler. Address presented before A.S.M.E.

### BRASS

**Forging.** Press Working and Forming of Metals—The Hot Press Forging of Brass, E. V. Crane. Metal Stampings, vol. 4, no. 1, Jan. 1931, pp. 39–42 and 72, 5 figs. Chemical composition of brass for forging; common practice in producing brass press forgings.

# C

### CAR AXLES

**Lubrication.** The Isothermos Axle Box. Engineering, vol. 131, no. 3392, Jan. 16, 1931, pp. 76–77, 2 figs. Axle box, which has been increasingly employed for some years past on several Continental railways and street cars, as well as in United States, Canada, and other parts of world; it is claimed that this axle box will run for 100,000 m. without refilling or other attention.

### CAR RETARDERS

**Power Supply.** New Haven Develops Unique Power Supply for Retarders at Providence Yard, W. F. Follett. Ry. Signaling, vol. 89, no. 1, Jan. 1931, pp. 11–12 and 14, 4 figs. Special motor-generator in combination with storage battery reduces power consumption to 30 watts per classified car when yard is being operated at capacity; importance of automatic switching.

### CARS

**Aluminum.** Auslaendische Erfahrungen im Bau von Strassenbahn- und Eisenbahnwagen aus Aluminium und seinen Legierungen (Experiences Outside of Germany in Construction of Railroad and Street Cars of Aluminum and Its Alloys), P. M. Haenni. Zeit. fuer Metallkunde, vol. 23, no. 1, Jan. 1931, pp. 12–18, 12 figs. Experiences of Aluminum Limited, Geneva; use of light metals for framework, covering and truck; technique of light-metal car construction; disadvantages as compared to advantages, and economic aspects.

**Dynamometer.** Making Locomotive Performance an Exact Science. Ry. Jl., vol. 37, no. 1, Jan. 1931, pp. 19–20 and 22, 5 figs. Equipment and operating characteristics of laboratory on wheels which assures peak efficiency in tonnage train operation on Buffalo Rochester, and Pittsburgh railway; test procedure and results.

**Refrigerator.** The "Dry-Ice" Refrigerator Car, C. L. Jones. Ice and Refrig., vol. 80, no. 2, Feb. 1931, pp. 113–114, 2 figs. Results of investigations on use of dry-ice in refrigerator cars; design and operating features. Before Am. Fruit and Vegetable Shippers' Assn.

### CASE HARDENING

**Nitriding.** Thermo-Diffusion of Elements in Steel, J. H. Hruska. Heat Treat. and Forging, vol. 17, no. 1, Jan. 1931, pp. 35–39, 4 figs. Tables and graphs give data on analyses of steels used in nitriding; relationship between time and temperature upon depth of chromium penetration into steel; diagram showing number of crystals per sq. in. as index to normality of steels; thermo-diffusion of vanadium and silicon.

### CAST IRON

**Alloy.** Alloy Additions Improve Gray Iron Pressure Castings, F. J. McGrail. Foundry, vol. 59, no. 2, Jan. 15, 1931, pp. 52–55, 11 figs. Effect of chromium and nickel addition on strength properties and crystal structure of cast iron for highly stressed parts.

Cupola Melting of High Test Cast Iron, F. B. Coyle. Metal Progress, vol. 19, no. 2, Feb. 1931,

pp. 46–50, 3 figs. Cupola practice in manufacture of high-test cast iron with data on composition of charges and physical properties of product; table lists of industrial applications of high-test alloy cast iron. Abstract of paper for West. Metal Congress.

Verbesserung von Gusseisen durch Legierung und Ueberhitzung (Improvement of Cast Iron by Alloying and Superheating), E. Schuez. Mitteilungen aus den Forschungsanstalten, vol. 1, no. 2, Nov. 1930, pp. 34–40, 4 figs. Price 2.50 m. Metallurgical definition of cast iron; author states that iron containing less than 1.7 per cent carbon, that is, without ledeburite or graphite, or iron whose ledeburitic cementite is brought partially or wholly to disintegration through subsequent annealing, is no longer cast iron, but steel or malleable cast iron; properties of different alloys and their effects on properties of cast iron.

**Properties at High Temperatures.** The Strength of Grey Cast Iron at Elevated Temperatures. J. W. Donaldson. West Scotland Iron and Steel Inst.—Jl., vol. 38, pt. 2, Nov. 1930, pp. 11–17 and (discussion) 17–20, 14 figs. Investigations to determine temperature stress curves of series of plain and alloy irons, influence of previous heat treatment on temperature stress curves, and effect of low silicon and various alloy additions on strength of cast iron at elevated temperatures both as cast and after heat treatment.

### COAL

**Carbonization, Low Temperature.** Etat présent de la technique de la carbonisation à basse température de la préparation d'anthracites artificiels (Present State of Low Temperature Carbonization in Preparation of Artificial Anthracite), C. Berthelot. Revue de Métallurgie, vol. 27, no. 12, Dec. 1930, pp. 672–679. Revue of developments in England and Central Europe with data on economy of process, capacity of various installations, and actual production.

**Handling Equipment.** Coal and Ash Handling for Boiler Fifty Feet Under Chicago River, T. H. Monaghan. Heat, Piping and Air Conditioning, vol. 3, no. 2, Feb. 1931, pp. 116–118, 7 figs. Two unusual features of heating system of Chicago Merchandise Mart are piping of high pressure steam to top of building and direct radiation located on perimeter of building, other spaces being heated by ventilating air; capacity of boilers; design and operating characteristics of coal bunkers and conveyors; ash removed through tunnel to lake.

**Pulverizers.** A New Unit Pulverizer. Mech. World, vol. 89, no. 2299, Jan. 23, 1931, pp. 78–79, 1 fig. "Dunston B" power station of Newcastle-on-Tyne Electric Supply Co., have six Clarke Chapman water-tube boilers 625 lb. per sq. in. pressure and 825 deg. fahr. superheated-steam temperature, each of 156,000 lb. evaporation per hr. along with complete pulverized-fuel equipment for four of boilers, which will be latest designs of their "Resolutor" unit pulverizer of 5 tons of coal per hr. capacity, taking coal with 8–15 per cent moisture, and grinding equivalent to 75–80 per cent through 200-mesh screen, that is, 10 tons of coal per boiler per hr.

### CONTAINERS

**Freight Shipment.** Containers Used in Co-ordinated Freight Service. Ry. Age, vol. 90, no. 4, Jan. 24, 1931, pp. 249–250, 2 figs. As means of reducing long distance trucking over highways and of co-ordinating railway and highway service, group of trucking companies in Ohio have organized Cargo Transport, Inc., as forwarding company using containers for movement of freight over lines of Cincinnati and Lake Erie between Cincinnati, Ohio, and Toledo; operation advantages.

### COOLING TOWERS

**Hamon Type.** Les réfrigérants à cheminée à contre-courant et à aérage lateral étagé (Cooling Towers With Counter-flow and Lateral Air Admission), W. Kopp. Génie Civil, vol. 97, no. 25, Dec. 20, 1930, pp. 616–619, 15 figs. Merits of principal types regarding construction and maintenance; sketches illustrate Hamon type.

### COUNTING MACHINES

**Principles of.** Counting and Packaging Machine Makes Articles Count Themselves, S. G. Koon. Iron Age, vol. 127, no. 4, Jan. 22, 1931, pp. 324–326, 2 figs. Principles of device for automatically feeding, counting, and packaging predetermined number of coins, screws, washers, buttons, or other articles brought out by Asa S. Cook Co., Hartford, Conn.

### CRANES

**Portable.** Recent Developments in Mobile Petrol-Electric Cranes. Ry. Gaz., vol. 54, no. 2, Jan. 9, 1931, pp. 49–51, 3 figs. Design and operating characteristics of Super-Mobile type of crane, in which whole superstructure is designed to revolve, so enabling crane to operate in confined space; control equipment; specifications of 1, 2, 3½–5, and 6 ton cranes.

**Shipyard.** Unusual Gantry Crane Handles Speed Boats and Cruisers, D. S. Ferree. Matls. Handling and Distribution, vol. 5, no. 4, Jan. 1931, pp. 31 and 54, 2 figs. Crane used by Horace E. Dodge Boat and Plane Corp., Newport News, Va., makes possible straight line production; it is 6-ton capacity, of 3-motor, cage control type; while main span is only 34 ft. 6 in., cantilever or overhang is 35 ft.

### CUPOLAS

**Design.** Der Schmelzvorgang im Kupolofen nach Ansichten und Auffassungen von Facherfindern (Melting Process in Cupolas According to Opinions and Theories of Expert Authorities), C. Rein. Giesserei, vol. 18, nos. 2, 3 and Jan. 9, 1931, pp. 33–37, Jan. 16, pp. 58–64, and Jan 23, pp. 78–83, 30 figs. Combustion process in cupolas: different types of nozzle arrangements; different cupola designs based on patent literature of past 30 years.

### CUTTING METALS

**Tungsten Carbide Tools for.** Tungsten Carbide and Milling, F. H. Curtis. Am. Mach., vol. 74, no. 5, Jan. 29, 1931, pp. 211–213, 3 figs. Design, operation, and grinding of inserted-blade face-milling cutters, with data on feed and speed for various materials.

### CYLINDERS

**Heat Emission From.** Heat Emission From the Surfaces of Cast Iron and Copper Cylinders Heated With Low Pressure Steam, A. C. Willard and A. P. Kratz. Heat. Piping and Air Conditioning, vol. 3, no. 2, Feb. 1931, pp. 141–145, 2 figs. Paper presents results of recent tests on cast-iron and copper cylinders as illustration of well-known laws of heat transmission and emission under temperature conditions comparable with those which exist in heating buildings; test plan and procedure; test results; discussion of results; conclusions. Paper presented before Am. Soc. Heat. and Vent. Engrs.

# D

### DIES

**Die-Casting.** The Die Is the Heart of Die Casting Process. Foundry, vol. 59, no. 2, Jan. 15, 1931, pp. 65–68, 4 figs. Methods and equipment in manufacture of dies or molds for pressure die casting; data on permissible variation per inch of diameter or length taken from United States Army Ordnance Specifications.

**Punching.** Design of an Adjustable Gang Die for Punching Angle-iron, R. H. Stout. Machy. (N. Y.), vol. 37, no. 6, Feb. 1931, pp. 451–453, 3 figs. Sketches illustrate operation and principles of die with punching units which can be located quickly to suit different jobs by means of interchangeable lay-out rails; cost data on operation of adjustable gang punch and single punch.

**Stamping.** The Construction and Uses of Typical Dies, E. Heller. Metal Stampings, vol. 4, no. 1, Jan. 1931, pp. 19–23, 5 figs. Design and construction features and principles involved in application of various types of dies to general metal-stamping practice covered in series of articles; present instalment deals with cut-off dies.

### DIESEL ENGINES

**Automotive.** A Survey of Mobile-Type Diesel Engines, C. G. A. Rosen. Soc. Automotive Engrs.—Advance Paper, for mtg. Jan. 19–23, 1931, 5 pp., 2 figs. Problems involved in designing of high-speed Diesel engines that are to be commercially successful; combustion-chamber design; fuel-injection methods and devices; flexibility in utilization of variety of cheap, low-grade fuels; completeness and smoothness of combustion; reduction of vibration; and low first cost and maintenance.

Combustion and Design Problems of Light High-Speed Diesel Engines, E. F. Ruehl. Soc. Automotive Engrs.—Advance Paper, for mtg. Jan. 19–23, 1931, 10 pp., 14 figs. Relative merits of existing types of combustion-chamber and injection systems used in present commercial four-cycle engines; single-turbulence-chamber type offers most promising means to high mean effective pressures at low fuel consumption; application of single chamber principles and of stock injection system to flexible combustion control in De LaVergne high-speed engines.

**Manufacture.** The Manufacture of Diesel Engines. Brit. Motorship, vol. 11, no. 131, Jan. 1931, pp. 468–469, 8 figs. Standardization of design and production methods which enters into Diesel-engine production in particular reference to manufacture of M.A.N. machinery; illustrations of machines utilized in construction of engines during passage of various parts through works at Augsburg; standard cylinder sizes; airless and air-injection engines.

**Sandon.** A Separately-Scavenged Two-Cycle Airless-Injection Engine. Engineering, vol. 131, no. 3393, Jan. 23, 1931, p. 120. Engine developed by Browett, Lindley & Co., Manchester, known as Sandon Diesel valveless engine; novel characteristics are independent scavenging, i.e., not crankcase scavenging, and forced lubricating system for moving parts; it is capable of being started instantaneously from cold; it is proposed to manufacture it with from one to four cylinders and ranging from 5 to 300 b.hp.

### DROP FORGING

**Tolerances.** Definite Drop-Forging Tolerances Will Aid in Lowering Costs, E. C. Clarke. Iron Age, vol. 127, no. 2, Jan 8, 1931, pp. 152–153 and 175, 1 fig. Factors affecting tolerances; increased die life balances extra cost of subsequent operations; closer forging tolerances secured by heavier equipment; advantage in specifying grinding locations; tolerances should be applied specially to controlling sizes.

# E

### ECONOMIZERS

**Rotating.** The Rotating Economizer, A. Weisselberg. Power, vol. 73, no. 4, Jan. 27, 1931, p. 150, 3 figs. Design and constructional features of Simmon rotating economizer; cost of foreign development higher than stationary economizer of equal capacity, but saving in space and reduced cost of installation may, in certain circumstances, more than offset higher price and justify its installation.

### ELECTRIC FURNACES

**High-Frequency.** Bronze Melted Economically in High Frequency Furnace, J. H. Williams. Metal Progress, vol. 19, no. 1, Jan. 1931, pp. 57–60, 4 figs. Application of high-temperature induction furnace to bronze foundry work in Providence, R. I., plant of General Fire Extinguisher Co.; data on layout of furnaces and auxiliary equipment built by Ajax Electric Furnace Corp., Trenton, N. J.

Power Problems in High-Frequency Melting, R. F. Northrup. Iron Age, vol. 127, no. 4, Jan. 22, 1931, pp. 318–322 and 367–368, 14 figs. Reliability and life of furnace and electric equipment; factors controlling melting efficiency and results obtained from specific installations in superheating gray iron and making different varieties of alloy steel; data on control of stirring effects.

### ELECTRIC WELDING

**Automatic Arc.** Automatic Arc Welding. Engineer, vol. 151, no. 3915, Jan. 23, 1931, p. 100, 5 figs. A. E. G. system of automatic arc welding was developed to improve upon welding by hand, which presents several well-known disadvantages; automatic machine can weld with higher current values and at greater speeds, while arc can be moved over work uniformly and be made to deposit metal smoothly and continuously; examples of A. E. G. welding machines and their application.

### ELEVATORS

**Electric—Dual System.** Dual Elevator System Placed in Operation at Pittsburgh. Eng. News-Rec., vol. 106, no. 5, Jan. 29, 1931, pp. 195–196, 2 figs. Trial installation in Westinghouse Building proves that express and local service in same shaftway is possible and safe; both cars are as unrestricted in their operation as under single-car system except that both cars must move in same direction and that safety devices govern their speed when they approach one another; details of dual system; saving in weight effected by utilizing aluminum for car sling and platform framing; aluminum and micarta used for car inclosure.

Operating Two Elevator Cars in One Hoistway, H. D. James. Power, vol. 73, no. 3, Jan. 20, 1931, pp. 100–103, 8 figs. In first commercial installation of its kind, two cars run on same guide rails, with another set of guide rails for counterweights; each elevator car in office building of Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa., rated at 3000 lb. at 600 ft. per min.; floor-button system of control and full-automatic operation; design and operating characteristics; plan and elevation views of hoistways.

The Dual Elevator Has Come, A. T. North. Arch. Forum, vol. 54, no. 2, pt. 2, Feb. 1931, pp. 235–236, 4 figs. Development of dual elevator means material decrease of building service areas with consequent increase in rentable floor area, great addition to economic height, with greater capacity, speed, and efficiency of service; plan of shaft top car and bottom car; sectional diagrams of shaft with dual elevator; arrangement of two cars, system of counterweights; automatic safety device stops cars whenever they approach each other too closely, similar in principle to block system in subway transportation.

### ENGINEERING

**Progress in 1930.** Jahresschau der Technik 1930 (Annual Review of Engineering in 1930). V.D.I. Zeit., vol. 75, no. 1, Jan. 3, 1930, pp. 5–32, 24 figs. Progress in design, construction, manufacture, and operation of heat power engines, hydraulic machinery, electric motors, and transformers, etc.; production and operation progress in mining, metallurgy, machine tool industry, welding, textile industry, ceramic industry, agricultural machinery, chemical industry, bridge and building construction, hydraulic engineering, railroad engineering, aeronautic engineering, shipbuilding, automotive engineering, telephone, telegraphy and radio, municipal engineering, research in engineering physics.

### ENGINEERS

**Status.** Economic Status of European Technicians, A. Trowbridge. Military Engr., vol. 23, no. 127, Jan.-Feb. 1931, pp. 57–60. Status of engineers, chemists, physicists, geologists, and biologists in Western European Countries whether engaged in instruction in technical schools or universities as experts in industry or in government technical services.

# F

### FLOW OF FLUIDS

**Models.** Experimentalle Behandlung der Stroemungslehre im physikalischen und technischen Unterricht (Experimental Treatment of Hydrodynamics and Aerodynamics in Physical and Engineering Instruction), B. Eck. Zeit. fuer Technische Physik, vol. 11, no. 12, 1930, pp. 506–511, 35 figs. on 5 special supp. plates. Principle of similitude; study of flow of liquids and gases in channels of various forms and around obstacles of various shapes, by means of models by strewing pulverized substances on surface of stream.

### FORGE SHOPS

**Practice.** Heating for Forging, R. M. Keeney. Metals and Alloys, vol. 2, no. 1, Jan. 1931, pp. 3–7, 7 figs. Fundamentals of forging practice and effect of different forging methods on physical properties; data on forging temperatures of various steels and effect of rate of heating on heat penetrations at 2200 deg. fahr. for different sizes and shapes; design and requirements of forging furnaces.

### FORGINGS

**Steel.** A New Forging Defect, Its Cause and Cure, W. E. Jominy and A. M. Steever. Metal Progress, vol. 19, no. 1, Jan. 1931, pp. 94–97, 6 figs. Investigation of defect due to localized carburization occurring during heating bar stock or billets in forging furnace; microphotograph illustrates crystal structure of various steels.

# G

### GAGES

**Optical.** Optical Coincidence Gage, I. C. Gardner. Am. Mach., vol. 74, no. 4, Jan. 22, 1931, pp. 155–157, 4 figs. Principles and design of instruments built by Bausch & Lomb Optical Co.; probable error of single setting is approximately plus or minus 0.0004 in.

**Strain.** Stress Analysis by Strain Gages, T. W. Greene. Product Eng., vol. 2, no. 1, Jan. 1931, pp. 11–13, 5 figs. How to use these instruments and how to interpret resulting data for analyzing stress distribution in old and new designs.

### GAS ENGINES

**Testing.** Versuche an der Gasmaschine (Tests on Gas Engines), A. Schnuerle. V.D.I. Zeit., vol. 75, no. 4, Jan. 24, 1931, pp. 101–105, 24 figs. Investigation of effect of mixture ratios on output, gas consumption of 100 hp. storage engine for operation with gas of different heating values; graphs illustrate air and gas consumption at various loads, temperatures of important engine parts, and various types of indicator diagrams; effect on operating economy of changes in charge obtained by variation of valve lift.

### GASOLINE ENGINES

**Efficiency.** Induction, Distribution, and Turbulence in Petrol Engines, S. J. Davies. Engineer, vol. 151, no. 3913, Jan. 9, 1931, pp. 51–52, 2 figs. Editorial comment and discussion of paper read before Institution of Mechanical Engineers dealing with certain fundamental factors affecting efficient operation of gasoline engines.

### GEARS

**Design.** Long and Short Addendum Gears, A. B. Cox. Am. Mach., vol. 74, no. 5, Jan. 29, 1931, pp. 196–198, 6 figs. Sketches illustrate how long and short addendum gears can be easily produced with standard cutters and assembled at standard center distances, with particular regard to strengthening of gears and reduction of noise: integral contact gearing with long and short addenda for electric locomotive service.

**Heat Treatment.** Modern Heat Treating in Gear Plant, E. F. Davis. Heat Treat. and Forging, vol. 17, no. 1, Jan. 1931, pp. 65–68, 6 figs. Organization and equipment of new gear plant of Warner Gear Co., Muncie, Ind., with capacity of 3000 transmissions daily; data on temperatures and capacities of furnace.

**Worn, Dimensions of.** Ermittlung der Verzahnungsmasze von Verschlissenen Zahnraedern (Determination of Gear Dimensions of Worn Gears), F. Riegel. Werkstattstechnik, vol. 25, no. 1, Jan. 1931, pp. 3–10, 6 figs. Tabulation of formulas for principal types of gears which permit by means of measurement of values not subject to wear, determination of all necessary dimensions for manufacture of new gears; examples illustrate application.

### GRINDING MACHINES

**Large.** Gross-Schleifmaschinen (Large Grinding Machines), Weil. Maschinenkonstrukteur, vol. 64, no. 1, Jan. 10, 1931, pp. 2–7, 10 figs. Design, performance data and power requirements of principal makes of German grinding machines including Naxos-Union, Frankfurt, a.M.; J. C. Reinecker, Chemnitz, Friedr. Schmaltz, Offenbach a.M., Diskuswerke, Frankfurt, a.M., Mayer & Schmidt, Offenbach a.M.

# H

### HARDNESS-TESTING MACHINES

**New.** A New Hardness Testing Machine. Ry. Engr., vol. 52, no. 612, Jan. 1931, p. 33. Direct-reading machine, rapid in operation and well adapted for testing mass production work; design and operating features.

Die Haertepruefung mit Tiefenmessung (Hardness Testing With Depth Measurements), O. Dettinger. Maschinenbau, vol. 10, no. 1, Jan. 1931, pp. 14–18, 8 figs. New machine for depth measurement method utilizing ball of 2.5 mm. diam. and load of 187.5 kg.; investigation of accuracy of depth measurement methods with regard to determination of Brinell hardness; possibility of finding tensile strength by means of depth-measurement method.

### HEAT INSULATION

**High Temperatures.** Insulation for High Temperatures, E. F. Zeiner. Power, vol. 73, no. 3, Jan. 20, 1931, pp. 104–106, 4 figs. Discussion of various types of pipe covering suitable for temperatures of 600 deg. and over; requirements of high-temperature insulation materials; curves illustrating thermal conductivity of furnace insulation; results of mechanical tests; insulating cements.

### HEAT TRANSMISSION

**Research.** Studies in Heat Transmission, A. P. Colburn and O. A. Hougen. Univ. Wis.—Eng. Experiment Station—Bul., no. 70, Oct. 1930, 158 pp., 40 figs. Contents consists of following sections: operation of tubular gas condensers; principles of heat transmission; previous experimental investigations; theoretical discussion; theoretical equations for condensation and for processes of heat and mass transmission; experimental apparatus and procedure; calibrations; calculating transmission coefficients from experimental data; summary of equations; summary of important units; bibliography and tables of experimental data.

### HEAT TREATMENT

**Equipment.** Many Sizes and Parts Heat Treated by Brown and Sharpe, E. W. Freeman. Metal Progress, vol. 19, no. 1, Jan. 1931, pp. 61–65, 8 figs. Layout and operation of heat-treating furnaces and auxiliary equipment including carburizing and annealing furnaces, pot furnaces, tempering furnaces, and high-speed furnaces.

**Fused Salt Baths.** Some Unusual Metallurgical Applications and Uses of Fused Salt Baths, W. J. Merten. Fuels and Furnaces, vol. 9, no. 1, Jan. 1931, pp. 51–52. Decomposition of nitrides in cyanided parts and in arc-welded parts, blueing steel surfaces to prevent corrosion, and obtaining maximum use of metal by means of fused salt baths and high-temperature salt baths.

### HIGH-SPEED STEEL

**Influences of Nickel and Manganese.** Ueber den Einfluss von Nickel und Mangan auf die Eigenschaften von Schnelldrehstahl (Effect of Nickel and Manganese on Properties of High-Speed Steel), V. Ehmcke. Kruppsche Monatshefte, vol. 11, Dec. 1930, pp. 295–315, 35 figs. Investigation of steel of normal composition, but containing nickel addition of from 2 to 50 per cent; microphotographs and curves illustrate results of hardening and tempering tests with regard to influence of increased quantity of austenite structure.

### HYDRAULICS

**Research.** Forschungsarbeiten auf dem Gebiete der technischen Hydrodynamik (Research Studies in the Province of Engineering Hydrodynamics), S. Erk. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, no. 1, Jan. 1931, pp. 19–27, 6 figs. Review of progress made by German research workers in study of 68 hydrodynamic problems; loss of head in liquids in turbulent flow; curved channels; diverging and converging conduits; discharge necks; applications of hydraulics to construction of machines, handling of materials, ship building, waterways improvement, etc.

### HYDROELECTRIC POWER DEVELOPMENTS

**St. Lawrence Dam.** St. Lawrence Engineers Favor One-Dam, Two-Step Plant at Massena. Elec. World, vol. 97, no. 2, Jan. 10, 1931, p. 82, 1 fig. St. Lawrence power development commission has reported to American section of Joint International Board of Engineers that it favors third method of procedure which is called "original engineering plan for developing, cheaply and safely, approximately 2,000,000 hp.;" plan contemplates one-dam two-stem 85-ft.-head development at Massena Point, N. Y.

### HYDROELECTRIC POWER PLANTS

**Bellows Falls, Vt.** Bellows Falls Hydro-Electric Development on the Connecticut River, U. S. A. Engineering, vol. 131, no. 3393, Jan. 23, 1931, pp. 97–100, 25 figs. partly on supp. plates. Particulars of phenomenal flood conditions of November 1927, when plant was under construction; old dam at head of Falls has been replaced by new structure with object of securing better pond control; roller gates, longest of their type in United States, are of M.A.N. type, and consist of steel cylinders 13½ ft. in diam. and 121 ft. long o.a., to which are attached steel aprons; combination of roller gates and stanchion flashboards provides flexible operating conditions.

# I

### ICE PLANTS

**Design.** Modern Ice Plant Economics, R. T. Brizzolara and E. C. Soares. Refrig. Eng., vol. 21, no. 2, Feb. 1931, pp. 101–105, 128 and 134, 4 figs. Survey of all elements of modern plant design as brought about by economic outlook of industry; electrical features specially treated; ice storages; tanks and evaporators; tank-room equipment.

### IMPACT TESTING

**Notched-Bar.** A Direct Method for Obtaining Stress-Strain Diagrams of Notched Bar Impact Test, T. Asano. Ryojun College Eng.—Memoirs, vol. 3, no. 2, Oct. 1930, pp. 137–144, 13 figs. partly on supp. plates. Direct method devised for taking photographs of stress-strain diagrams in notched-bar impact test of Izod type: test-piece must be considered as elastic cantilever with load elastically connected through notch; oscillating stress during impact is mainly due to rapid oscillation of cantilever.

### INDUSTRIAL MANAGEMENT

**Budget Control.** Charting and Budgeting

Your 1931 Profit Course, C. E. Knoeppel. Iron Age, vol. 127, no. 4, Jan. 22, 1931, pp. 296–301, 3 figs. Method of investigation of factors controlling profits and losses and methods of planning budget variable according to economic situation.

**Cost Accounting.** Fabriksabrechnung der Einzel- und Kleinserienfertigung (Cost Accounting for Small Series and Unit Production), J. H. Hazuka. Sparwirtschaft, vol. 8, no. 12, Dec. 1930, pp. 547–554. Outline of cost accounting system including budgeting, and loss and profit calculation.

Durchfuehrung industrieller Rechnungsverfahren (Carrying Out Industrial Accounting Processes), G. Lehmann. V.D.I. Zeit., vol. 75, no. 3, Jan. 17, 1931, pp. 63–68. Theories of accounting; "relativity" of cost figures, cost accounting.

Einheitsbuchfuehrung in mittleren Maschinenfabriken mit Einzelfertigung (Cost Accounting in Medium Sized Plant for Jobbing Manufacture of Machinery), A. Lenk. Sparwirtschaft, vol. 8, no. 12, Dec. 1930, pp. 557–563. Requirements of general cost accounting system with particular regard to wages and materials; effect of capacity on various cost items.

**Cost Reduction.** Organization for Cost Reduction, W. Rautenstrauch. Soc. Indus. Engrs.—Bul., vol. 12, no. 12, Dec. 1930, pp. 9–12. Factors discussed as necessary for organization for cost reduction are: design of product; nature of business; manufacture of product; merchandizing of product; financial design of business; organization; management policies.

**Depreciation.** Depreciation; A Direct Cost, T. B. Frank. Iron Age, vol. 127, no. 5, Jan. 29, 1931, pp. 373–375 and 414. Review of principles of proper depreciation accounting; examples illustrate that current values must determine depreciation costs of machinery.

**Inventory Control.** Graphic Inventory Control, E. J. Keller. Factory and Indus. Mgmt., vol. 81, no. 2, Feb. 1931, pp. 241–244, 6 figs. Inventory variations; variations of material specifications; variation of production from schedule; changing schedule; checking by inventory; change in design.

**Organization for Continuous Production.** Organisation rationnelle des Ateliers et Magasins Travail à la chaine (Organization of Shops and Storerooms for Continuous Production), H. Levi. Revue d'Electricité et de Mécanique, no. 14, Nov.-Dec. 1930, pp. 26–35, 12 figs. Complete analysis of operations to be performed, and application to actual cases.

**Production Control.** Arbeitsvorbereitung (Planning of Work), H. Freund. V.D.I. Zeit., vol. 75, no. 4, Jan. 24, 1931, pp. 107–111, 7 figs. Fundamental factors in production planning; human element, place of work, and work distribution; wage systems and contract work; record system, etc.

Einfluss der Normung auf Stueckzahl und Preis (Effect of Standardization on Lot Size and Price), P. Grodzinski. Maschinenbau, vol. 10, no. 2, Jan. 15, 1931, pp. 37–39, 4 figs. Graphic methods for investigating relations between various cost items and lot sizes, with particular regard to advantages of standardization.

Ermittlung von wirtschaftlichen Losgroessen bei Reihenfertigung (Determination of Economical Lot Sizes in Series Production), A. A. Katz. Maschinenbau, vol. 10, no. 2, Jan. 15, 1931, pp. 33–36, 8 figs. Analytic development of graphic methods for determining requirements of capital, which is decisive in determining economic lot sizes for complex finished products; derivation of formula for minimum overhead as function of lot size.

**Production Planning.** Grosszahlforschung in Mechanischen Betrieben (Statistical Research in Machine Shop), E. Franke. Werkstattstechnik, vol. 25, no. 2, Jan. 15, 1931, pp. 35–37, 7 figs. Laws of large numbers as applied to determination of feed and speed of different types of machine tools and materials; life frequency curve for planning and management purposes.

**Time Study.** A Simplified Time Study for a Tool-Room Bonus System, T. Turner. Machy. (N. Y.), vol. 37, no. 6, Feb. 1931, pp. 433–435, 6 figs. Principles of tool-room time study of Westinghouse Electric & Mfg. Co.; system increased production 50 per cent and wages 25 per cent; different blank forms are illustrated.

### INTERNAL-COMBUSTION ENGINES

**Manifolds.** Induction Manfoilds for Internal-Combustion Engines, C. S. Kegerreis. Motive Power, vol. 2, no. 1, Jan. 1931, pp. 14–17, 4 figs. Consideration of such design practices as distribution by vaporization of fuel and cold starting in manifolding system; table of hot-spot areas on various engine intakes.

**Speed Recorders.** Measurement of Speed Fluctuation, P. L. Henderson. Engineer, vol. 151, no. 3915, Jan. 23, 1931, p. 104, 4 figs. Experimental work carried out by author at Engineering School, Sydney University; object was to devise simple, accurate and direct means of measuring fluctuation in speed of engine such as National gas engine and to compare this record with that of tachograph.

[See also AIRPLANE ENGINES; AUTOMOBILE ENGINES; DIESEL ENGINES; GAS ENGINES; GASOLINE ENGINES.]

# L

### LATHES

**Automatic.** Die Neuere Entwicklung der Mehrspindel Automaten (Brief Development of Multispindle Automat), P. Kelle. Werkstattstechnik, vol. 25, no. 1, Jan. 1931, pp. 10–13, 8 figs. Development and design of multispindle automatic lathes with regard to improved output, accuracy and ease of operation.

### LOCOMOTIVES

**Compound.** Eight-Coupled Compound Locomotive, Beira-Alta Ry. Locomotive, vol. 37, no. 461, Jan. 15, 1931, pp. 1–2, 1 fig. Design and constructional features of new type constructed by Henschel and Son, of Cassel, for Portuguese Beira-Alta Ry.; compounding carried out by De Glehn principle; cylinders 16.53 by 25.19 by 25.59; boiler pressure 225 lb. per sq. in.; tractive effort at 50 per cent boiler pressure 28,880 lb.; total engine wheel base 32 ft. 4 in.; weight of engine in working order 86 tons.

**Design.** Steam Locomotive Design: Data and Formulae, E. A. Phillipson. Locomotive, vol. 37, no. 461, Jan. 15, 1931, pp. 14–16. Boiler mountings; steam using auxiliaries; relation of dimensions of Ross safety valves to grate area and boiler pressure.

**Diesel Switching.** Diesel Shunting Locomotive, Central Argentine Railway. Ry. Engr., vol. 52, no. 612, Jan. 1931, pp. 31–32, 1 fig. Design, construction, and operating features of locomotive fitted with 100-hp. six-cylinder McLaren-Benz coal-starting Diesel engine with special type of transmission; principal dimensions of locomotive.

**Electric Freight.** Desirable Features of Locomotives for Interurban Freight Service, T. F. Perkinson. Elec. Ry. Jl., vol. 75, no. 2, Feb. 1931, pp. 87–89, 5 figs. Factors involved in determination of type of motive power which should be used for handling small amounts of freight on interurban railways; speed-tractive effort characteristics of typical 600-volt slow-speed locomotives, equipped with four 175 hp. motors, 70/15 gear ratio, 38 in. wheels.

Selecting Freight Locomotives for Interurban Lines, H. C. Hickock. Elec. Ry. Jl., vol. 75, no. 2, Feb. 1931, pp. 83–86, 4 figs. Proper choice of motive power will permit haulage of considerable amount of freight without increase in power supply of average interurban railway; table of comparison of slow-speed and high-speed 50-ton locomotives for freight haulage on interurban railroads; cost of hauling freight with 75-ton locomotives.

**Feedwater Treatment.** New York Central Builds Largest Treating Plant at Elkhart, Ind. Ry. Eng. and Maintenance, vol. 27, no. 1, Jan. 1931, pp. 38–41, 12 figs. Many refinements in design have been embodied in new facilities, which are designed to save 100 per cent annually on investment; constructional details of treating plant; filter construction; plan and elevation of chemical tanks; welded sludge piping.

**High-Pressure.** High-Pressure Locomotives, H. N. Gresley. Engineer, vol. 151, nos. 3916 and 3917, Jan. 30, 1931, pp. 138–141, and Feb. 6, pp. 164–167, 19 figs. partly on supp. plate, and (discussion) pp. 124–125. Also Ry. Gaz., vol. 54, no. 5, Jan. 30, 1931, pp. 153–158, 11 figs. Review of development; Delaware and Hudson 2-cylinder compound locomotives; Schmidt-Henschel 3-cylinder compound locomotives; Schwartzkopff-Loeffler 3-cylinder locomotive; 4-cylinder high-pressure compound locomotive, London and North-Eastern Railway; author, in designing this engine, thought it advisable to be content with only moderate increase in boiler pressure to 450 lb. per sq. in. Before Instn. Mech. Engrs.

The "James Archbald" High-Pressure Locomotive, E. C. Poultney. Ry. Engr., vol. 52, no. 612, Jan. 1931, pp. 21–26, 6 figs. Design, construction and operating features of locomotive for Delaware and Hudson, which has compound cylinders and uses superheated steam at 500 lb. per sq. in. pressure; comparison with other locomotives; cylinders 20½ by 35½ by 32 in.; driving wheels 5 ft. 3 in.; total engine weight 159 tons; total engine wheelbase 29 ft. 0 in.; compound tractive force, 70,300 lb.

**Oil-Electric Switching.** Oil-Electric Switching Locomotive, Canadian National Railways. Can. Ry. and Mar. World, no. 396, Feb. 1931, p. 65, 1 fig. Design, construction, and operating features of locomotive placed in regular service in St. Henry passenger car yards, Montreal, June 1930; list of principal dimensions; locomotive equipped with Westinghouse 6-cylinder oil engine with cylinders 9 by 12 in., normal rating of 400 hp. at 900 r.p.m., burning heavy fuel oil and working on solid-injection 4-stroke-cycle principle.

**Passenger.** New 4–6–2 Type Express Locomotives for the German Railways. Ry. Gaz., vol. 54, no. 1, Jan. 2, 1931, pp. 17–18, 5 figs. Design features of four-cylinder compound locomotives with bar framing; cylinders; high pressure, 17⅜ by 24 in., low pressure 25⅛ by 26⅜ in.; coupled wheels 6 ft. 1⅛ in.; total engine wheelbase 36 ft. 8½ in.; boiler pressure 235 lb. per sq. in.; total weight of engine in working order 95.27 tons.

New 4–6–4 Express Locomotives. Canadian National Rys. Locomotive, vol. 37, no. 461, Jan. 15, 1931, pp. 20–21, 2 figs. Locomotives designed for extended runs with International Limited train; cylinders 23 by 28 in.; coupled wheels 6 ft. 8 in. boiler pressure 275 lb. per sq. in.; tractive force with booster 53,500 lb.; total engine wheelbase; 40 ft. 4 in.; total engine weight in working order 356–400 lb.

**Performance.** Economics of Steam Locomotive Performance and Maintenance, E. Najork and R. Wichtendahl. Ry. Engr., vol. 52, no. 613, Feb. 1931, pp. 65–70, 14 figs. Thermal efficiency of modern types of locomotives with reference to entropy diagrams; commercial practicability of alternative solutions; typical operating cycles; turbo and ultra-high-pressure locomotives; coal vs. capital and maintenance costs; Hanomag 662 lb. pressure locomotive.

**Testing.** Thermic Syphons Tested at the University of Illinois. Ry. Age, vol. 90, no. 2, Jan. 10, 1931, pp. 141–146, 5 figs. Application to Mikado locomotive gives 8.47 per cent increase in general boiler efficiency, according to laboratory test report; responsibility for test results; general test procedure and program; main results of tests.

**Three-Cylinder.** New Three-Cylinder 4–6–2 Locomotives, Central Argentina Railway. Ry. Engr., vol. 52, no. 612, Jan. 1931, pp. 7–9, 5 figs. Locomotives have been built by W. G. Armstrong, Whitworth and Co. at Scotswood Works, Newcastle-upon-Tyne, and are equipped with Caprotti valve gears; cylinders (with liners) 19½ by 26 in.; coupled wheels 6 ft. 2½ in.; boiler pressure 225 lb. per sq. in.; tractive force at 85 per cent boiler pressure, 38,000 lb.; total weight of engine in working order 97 tons; total engine wheelbase 35 ft. 1¾ in.

# M

### MACHINE SHOPS

**Equipment.** Shop Equipment Review. Am. Mach., vol. 74, no. 3, Jan. 15, 1931, pp. 75–154, numerous figs. Semi-Annual résumé of machinery, tools, mechanisms, parts, and materials described in Shop Equipment Review sections of American Machinist during last six months of 1930, and also similar résumé of Engineering Workshop Equipment sections of European Edition for June, 1930, to Nov. 1930.

### MACHINE TOOLS

**Clamping Devices.** Pressluft- und Pressoel-Spanngeraete sind auch fuer kleine Stueckzahlen wirtschaftlich (Pneumatic and Hydraulic Clamping Devices Are Economical for Small Lot Sizes), E. Preger. Maschinenbau, vol. 10, no. 2, Jan. 15, 1931, pp. 43–47, 24 figs. Practical examples illustrate ways of adapting commercial clamping devices to multiplicity of shapes and sizes of work; sketches illustrate mechanical details; data on accuracy and saving of time with different types of chucks.

**Design.** Machine Tool Design May Be Widely Affected by New Cutting Materials, F. E. Cardullo. Iron Age, vol. 127, no. 2, Jan. 8, 1931, pp. 154–159, and 219, 2 figs. Elements of machine-tool design; effect of tungsten-carbide tool development on design and use.

**Electric Control.** Control of Individually Driven Machine Tools, C. H. S. Tupholme. Mech. World, vol. 89, no. 2296, Jan. 2, 1931, pp. 9–10. Maximum output and greatest flexibility of operation are obtained only when motor-driven machine tools are equipped with some form of automatic control; all automatic con-

trolling devices divided into two classes, one known as time acceleration starters, and other as current-limit starters or series relays; complete control from one point is of greatest value for many classes of work, as workman can change speed at will as best suits work as it progresses.

### MALLEABLE-IRON CASTINGS

**High-Test.** Ueber hochwertigen Temperguss (High-Test Malleable Cast Iron), E. Piwowarsky. Giesserei, vol. 18, no. 1, Jan. 2, 1931, pp. 19–24, 14 figs. Advantages of malleable over steel and gray-iron castings; white-heart malleable; influence of wall thickness and manganese content; metallurgical advantages of black-heart malleable; possibilities of treatment; influence of chemical composition, initial temperature, cooling conditions, and special elements, especially nickel and chromium; price of malleable castings.

**Production.** Betriebsergebnisse und Anwendungsgebiete der neuzeitlich hergestellten verschiedenen Tempergussarten (Modern Practice in Manufacture of Malleable Iron Castings), R. Stotz. Giesserei, vol. 18, no. 1, Jan. 2, 1931, pp. 1–8, 10 figs. Comparison of European and American malleable-iron foundries with regard to melting process; advantages of cupola melting and black-heart castings; uniformity in chemical composition of cupola-melted malleable; special peculiarities of black-heart malleable.

### MATERIALS

**Strength, Nature of.** Ueber die Natur der Festigkeit (Strength Characteristics), M. Polanyi. Mitteilungen der Deutschen Materialpruefungsanstalten, no. 8, 1930, pp. 113–119, 15 figs. Nature of strength of deformed crystals rests on connecting line between two limit cases of completely regular and completely irregular matter; crystalline matter can be plastically deformed, by replacing densest atomic cells parallel to one another.

### MATERIALS HANDLING

**Equipment.** Conveyors and Mechanical Handling, F. Johnstone Taylor. Mech. World, vol. 89, nos. 2296, 2297, and 2298, Jan. 2, 1931, pp. 3–6, Jan. 9, pp. 32–34 and Jan. 16, pp. 60–62, 19 figs. Jan.: Unloading systems; general principles of grabs; types of grabs; mechanism and working of grab; Blaw-Knox single-line bucket. Jan. 9: Barnards chain-button system; automatic grabs, telpher systems. Jan. 16: Chain conveyors; bucket elevators, Bennis system.

**Industrial Plants.** Keeps Stock Moving From Entrance to Shipping Dock. Iron Age, vol. 127, no. 4, Jan. 22, 1931, pp. 312–317 and 370, 7 figs. Layout of conveyors and material-handling facilities at new manufacturing unit of Electric Auto-Life Co., Toledo, Ohio, for making 10,000 starters and like number of generators per day; plant uses daily 120 tons of steel, largely in sheets and strip, 20 tons of cast iron and 40 tons of copper.

**Ore Unloaders.** Huge Ore Unloaders at Toledo Pick Up 17 Tons of Ore at a Bite. Port and Terminal, vol. 10, no. 11, Dec. 1930, pp. 7–8, 3 figs. Features of electrically driven unloaders recently erected on Chesapeake and Ohio Railroad docks, Hocking Valley Division, at Presque Isle, Toledo, there are eight motors, totaling 1060 hp. on each unloader; transformer stations are three phase 60 cycle, for 6600 volts incoming, and 440 volts outgoing.

### MERCURY-VAPOR POWER PLANTS

**Hartford, Conn.** Mercury Turbine Averages 10,310 B.t.u./Kw.-Hr. Elec. World, vol. 97, no. 2, Jan. 10, 1931, pp. 110–111, 1 fig. Between Feb. 4 and Dec. 14, 1930, inclusive, mercury boiler and turbo-generator unit at South Meadow station of Hartford Electric Light Company produced total net output of 112,238,940 kw-hr. at average rate of 10,310 B.t.u.; unit was available for service 82.3 per cent of time allowing for all causes of shut-down.

10,000-Kw. Mercury-Turbine Plant. Engineering, vol. 131, no. 3392, Jan. 16, 1931, pp. 65–68, 14 figs. partly on supp. plate. Method of producing power from fuel through medium of mercury vapor, conceived and worked out by W. LeRoy Emmet, of General Electric Co., Schenectady, N. Y.; primary object of process is provision of thermodynamic engine which is capable of using effectually higher ranges of temperature than are convenient and practicable with steam; details of 10,000-kw. plant at South Meadow Station of Hartford Electric Light Co.

### METALLURGY

**Developments in 1930.** Developments in Ferrous and Non-Ferrous Metallurgy During 1930, H. M. Boylston. Fuels and Furnaces, vol. 9, no. 1, Jan. 1931, pp. 19–31. Developments in manufacture of pig iron, wrought iron, steel, foundry practice, carburization, nitridation, alloys, heat treatment, temperature measurement, spectrographic analysis.

### METAL DRAWING

**Deep.** Ein neues pruefgeraet fuer Tiefziehbleche (New Testing Apparatus for Deep-Drawn Sheets), G. Sachs. Mitteilungen der Deutschen Materialpruefungsanstalten, no. 8, 1930, pp. 80–85, 7 figs. Deficiencies of present testing methods and devices; apparatus developed is in form of drawing nozzle and method is termed wedge drawing test; it is claimed to be superior to deep drawing test for exact determination of drawability. From Metallwirtschaft, vol. 9, 1930, p. 213.

### MOTOR BUSES

**Road-Rail Car.** The New "Ro-Railer," L.M.S.R. Ry. Gaz., vol. 54, nos. 4 and 5, Jan. 23, 1931, pp. 123–124, and Jan. 30, pp. 159–162, 10 figs. Particulars of new L.M.S.R.-Karrier design, to meet requirements of passenger and freight transportation both by road and rail; list of principal data; elevation and plan views.

# O

### OPEN-HEARTH FURNACES

**Design.** Four Talbot de 250 tonnes des Aciéries de Ruhrort-Meiderich Allemagne [Talbot Furnace of 250 Tons at Steel Plant Ruhrort-Meiderich (Germany)]. Génie Civil, vol. 97, no. 23, Dec. 6, 1930, pp. 553–556, 9 figs. Sketches illustrate design of tipping furnace under construction by Demag; data on use of refractory materials.

**Rapid.** Rapid Open-Hearth Furnaces, N. E. Skaredoff. Iron and Coal Trades Rev., vol. 122, no. 3281, Jan. 16, 1931, p. 81. Furnaces designed by author and built at Kamaishi Steel Works in Japan; instead of usual two or three charges daily, it is possible to get five to six charges from each daily; furnace capacity 25 tons; charge is 20 to 30 per cent molten from blast furnace direct, 20 to 30 per cent cold pig, 35 to 50 per cent steel scrap; fuel is coke oven gas and coal tar; fuel consumption less than half of that for ordinary furnaces, per ton of product.

# P

### PENSTOCKS

**Germany.** Die Druckrohrleitung des Vermuntwerkes (Penstocks of the Vermunt Hydro-electric Power Plant), F. Bundschu. V.D.I. Zeit., vol. 74, no. 51, Dec. 20, 1930, pp. 1725–1728, 9 figs. Design and construction of twin-pipe penstock, 1960 m. long, operating under static head of 720 m., diameter varying from 1.34 to 1.77 m.; lower portion is reinforced with hoops 57 mm. thick; penstock was welded with water gas; details of joints, hoops, etc.

### PHOTOELECTRIC CELLS

**Industrial Applications.** Fitting Photo-Electric Tubes Into the Scheme of Automotive Production, J. Geschelin. Automotive Industries, vol. 64, no. 2, Jan. 10, 1931, pp. 64–66, 5 figs. Review of principal applications in automotive industry and general explanation of operating principles.

### PISTONS

**Light-Metal.** Vergleichende Versuche ueber Leichtmetall-Kolbenlegierungen (Comparative Tests of Light-Metal Piston Alloys), M. von Schwarz. Zeit. fuer Metallkunde, vol. 22, no. 12, Dec. 1930, pp. 417–419 and (discussion) 419–420, 6 figs. Results of tests undertaken as aid in manufacture of perfect light-metal piston; improvements effected by use of high-test light-metal alloys; machine for testing bearings under running load, developed by author.

### PLATES

**Rectangular, Strength of.** Strength of Rectangular Flat Plates Under Edge Compression, L. Schumann and G. Back. Nat. Advisory Committee for Aeronautics—Report, no. 356, 1930, 24 pp., 40 figs. Flat rectangular plates of duralumin, stainless iron, monel metal, and nickel were tested under loads applied at two opposite edges and acting in plane of plate; deflection and set measurements perpendicular to plane of plate were taken and form of buckle determined; data will be of use in design of floats, pontoons, wings, etc., of aircraft when plating is subjected to pressure against edges.

**Thin Flat, Stresses in.** Wrinkling Phenomena of Thin Flat Plates Subjected to Shear Stresses, F. Bollenrath. Nat. Advisory Committee for Aeronautics—Tech. Memo., no. 601, Jan. 1931, 34 pp., 37 figs. Review of method for calculating stress; test set-up and results, with graph and sketches illustrating stress distribution and wrinkling; tests with celluloid, duralumin, and brass plates; formula for determining load at wrinkling. Report from Jahrbuch 1930 der Deutschen Versuchsanstalt fuer Luftfahrt e.V.

### PRESSES

**Hydraulic.** The Development of the Hydraulic Press, E. Pfann. Metal Industry (Lond.), vol. 38, no. 1, Jan. 2, 1931, pp. 11–12. Large output of products which can be obtained from these machines, and possibility of varying products to obtain wide assortment of finished metal products. Translated abstract from Metallwirtschaft, vol. 9, pp. 706–8.

# R

### RAIL MOTOR CARS

**New Developments.** 1930 Developments in Railway Automotive Equipment, P. L. Mardis. Railroad Herald, vol. 35, no. 2, Jan. 1931, pp. 28–31, 3 figs. Outstanding development of visibility cab; oil and gas-electric cars and locomotives ordered in 1930; specific examples of service records.

**Propeller-Driven.** Technik und Wirtschaftlichkeit der Propeller-Triebwagen (Engineering Principles and Economy of Propeller Rail Motor Cars), O. Steinitz. Glasers Annalen, vol. 108, no. 2, Jan. 15, 1931, pp. 13–18, 5 figs. Propeller drive opens railroad traffic for combustion motor; advantages and experience with non-adhesive system; characteristics and deviations from previous practice; economic principles and possibilities of application.

### RAILROAD SIGNALS

**Interlocking.** Another Unique Interlocker on the Rock Island. L. Wyant. Ry. Signaling, vol. 24, no. 1, Jan. 1931, pp. 13–14, 2 figs. Telephone switch-board keys, mounted on track model, control signal selection on road selected by single-lever table interlocker.

### RAILROAD TRAIN CONTROL

**Automatic.** Great Western Automatic Train Control. Ry. Age, vol. 90, no. 3, Jan. 17, 1931, pp. 187–192, 8 figs. Twenty-four years' experience leads to notable extensions of automatic train control in England; design and operating characteristics.

### REFRIGERANTS

**Ammonia Compounds.** Die thermischen Eigenschaften von Ammoniakaten und aehnlichen Verbindungen und ihre Verwendung in Absorptions-Kaeltemaschinen (Thermic Properties of Halogen-Hydracid Ammonia Compounds and Their Use in Absorption Refrigerating Machines), R. Plank and L. Vahl. Forschung auf dem Gebiete des Ingenieurwesens, vol. 2, no. 1, Jan. 1931, pp. 11–18, 5 figs. Review of characteristics with data on vapor-pressure curves show that calcium-chloride "Ammoniakate" lithium-chloride "methylaminate" are suitable refrigerants for absorption machines.

### REFRIGERATING PLANTS

**Design.** Improving and Modernizing Ice Making and Refrigerating Plants, F. S. Strite. Ice and Refrig., vol. 80, no. 2, Feb. 1931, pp. 102–104. Economics of plant analysis; power factor choice dependent upon power costs; location of plant decided upon distribution convenience; building materials not as important as utility factor; survey of surroundings and analysis of operating costs necessary to insure profits.

### RIVETED JOINTS

**Fatigue Testing.** Dauerversuche mit Nietverbindungen (Fatigue Testing of Riveted Joints), K. Schaechterle. Stahlbau (Supp. to Bautechnik), vol. 3, nos. 24 and 25, Nov. 28, 1930, pp. 277–281, and Dec. 5, pp. 289–295, 31 figs. Information on fatigue testing and report on series of tests of riveted joints of steel St 37, made at testing laboratory of Stuttgart Institute of Technology; analysis of results and description of modes of failure.

### ROLLING MILLS

**Blooming Mills—Lubrication.** The Application of Pressure Lubricating Systems to Blooming and Continuous Mills, W. D. Hodson. Rolling Mill Jl., vol. 5, no. 1, Jan. 1931, pp. 47–50, 2

figs. Features and advantages of mechanical, pressure lubricating system for rolling mills; typical blooming and continuous-mill installations.

**Brass.** Cold Rolling Mills for Strip Metal. Engineering, vol. 131, nos. 3390 and 3391, Jan. 2, 1931, pp. 8–10, and Jan. 9, pp. 62–63, 8 figs. Mills constructed by W. H. A. Robertson and Co., Bedford, include four-high reversing mill, 11 in. by 22 in. by 32 in., and mill intended for cold rolling brass or other metal strip 24 in. wide; working rolls are of chrome-alloy steel hardened to 95 to 100 scleroscope hardness number; driving motor is 200 hp., and runs at 485 r.p.m.; similar mills are installed for one-direction rolling, arrangement being generally similar, but with reversing gear box omitted.

**Tables.** Recent Developments in Rolling Mill Table Construction, W. McKee. Rolling Mill Jl., vol. 5, no. 1, Jan. 1931, pp. 23–26, 2 figs. Application of individually electrically driven types of rollers to mill tables, together with developments in various designs of such rollers.

# S

### SAND BLASTING

**Steel Grit for.** Economies Effected by Using Steel Grit for Sand Blasting, W. J. Sorrow. Iron Age, vol. 127, no. 5, Jan. 29, 1931, pp. 392–394, 4 figs. Tests conducted by American Hardware Corp., showed one ton of steel grit to be equal to 20 tons of silica sand.

### SEAPLANES

**Design.** The Design of Sea-Going Aircraft, A. Gouge. Aeroplane, vol. 40, no. 2, Jan. 14, 1931, pp. 71–72, 74 and 76, 13 figs. Progress with design and operation of big flying boats; model test methods and interpretation of results; resistance curves, performance curves, and other characteristics are illustrated by graphs. Paper read before Roy. Aeronautical Soc.

### SHAFTS

**Vibrations in.** Torsional Flexibility in Gear Drives, W. A. Tuplin. Engineering, vol. 131, nos. 3391 and 3393, Jan. 9, 1931, pp. 37–39 and Jan. 23, pp. 101–104, 8 figs. Jan. 9: Conditions under which torque variations are reduced by shaft flexibility are investigated. Jan. 23: Application of principles investigated illustrated by numerical example of reciprocating-engine drive; procedure to be adopted in designing flexible-shaft drive.

### SHEET METAL

**Stamping Plant.** Straight-Line Travel 250 Ft. from Raw Material to Shipping Dock. Iron Age, vol. 127, no. 2, Jan. 8, 1931, pp. 165–168 and 176, 5 figs. Important features of new plant of City Auto Stamping Co., Toledo, Ohio, include short, straight-line flow of work across plant and handling facilities, which include traveling cranes in bays in which heavy material is handled and one conveyor line for assembly of fenders and another for removal of scrap by which means floor is kept practically free of scrap material; plant is 504 ft. long by 240 ft. wide.

**Testing.** Zur Pruefung der Oberflaechenbeschaffenheit von Blechen (Testing of Surface Properties of Plates), E. Gerold. Stahl und Eisen, vol. 51, no. 4, Jan. 22, 1931, pp. 104–106, 5 figs. Results of tests to determine roughness of plate surfaces with Kempf-Fluegge polarization smoothness tester made by Schmidt & Haensch, and with Askania smoothness tester; these and also an arrangement with photoelectric cell, can be successfully applied, but they are not recommended for acceptance testing.

**Working.** Blechziehen ueber Hoelzern Formen (Drawing of Sheet over Wooden Patterns), O. Kuehner. Maschinenbau vol. 10, no. 1, Jan. 1931, pp. 7–8, 7 figs. Design and operation of machine built by L. Schuler A.-G. Goeppingen for drawing sheets for automobile bodies for small production numbers.

Sheet Metal Working, J. L. Wiliams. Metal Industry (Lond.), vol. 38, no. 3, Jan. 16, 1931, pp. 87–90, 8 figs. Advances made in sheet-metal working; how drawing quality of sheet brass has been improved; drawing operations; alloys of aluminum requiring special treatment; spinning; advance in application of power press.

### SPRINGS

**Helical.** Druckbeanspruchte Kegelstumpffedern mit gerader Kraft-Weg-Linie (Helical Springs for Compression Loading With Straight-Force-Path Characteristics), S. Grosz. V.D.I. Zeit., vol. 74, no. 52, Dec. 27, 1930, pp. 1759–1762, 8 figs. Investigation of formulas for calculating helical springs of truncated cone shape; comparison of three types of springs with straight characteristics by means of space utilization number.

### STEAM

**Driers.** The Moynan Steam Dryer. Engineer, vol. 151, no. 3918, Feb. 13, 1931, p. 194, 5 figs. Drier manufactured by F. K. O. Moynan is known as "Ejectifier" and is in use at Barking, Stourport, and other large power stations and elsewhere, in conjunction with boilers of various types; it can be arranged to deal with flows of steam of widely different amount and at various pressures.

**Properties.** Further Solutions Through Use of the Heat Content-Pressure Diagram, L. Holdredge. South Power Jl., vol. 49, no. 2, Feb. 1931, pp. 66–70, 5 figs. Diagram intended for use in solving problems throughout steam cycle, particularly those beyond limitations of Mollier chart; calculation of six problems.

### STEAM ACCUMULATORS

**Power Storage With.** Production thermique de l'énergie et accumulation (Thermal Generation and Storage of Power), E. Rauber and J. Lebrun. Revue Générale de l'Electricité, vol. 29, no. 4, Jan. 24, 1931, pp. 143–152, 12 figs. Report at 2nd Power Conference, Berlin; storage of steam power; typical characteristics of steam and hot water storage are discussed; numerical data for both cases are given.

### STEAM-ELECTRIC POWER PLANTS

**Belgium.** Modern Power Practice in Belgium, D. Brownlie. Combustion, vol. 2, no. 7, Jan. 1931, pp. 38–40, 46 and 49, 6 figs. Progress in power generation moving at rapid-pace in Belgium, which has been one of centers of major industrial advancement for centuries past, especially in connection with technique of iron and steel production; design details of new Schelle station of Societe Generale Belge de Production d'Electricite; station is designed for ultimate capacity of 500,000 kw., of which 90,000 kw. is now available from section just completed; other power stations in Belgium are discussed which exemplify modern practice.

**Cleveland, Ohio.** Ashtabula Adds 150,000 kw. to Cleveland Electric System. Power Plant Eng., vol. 35, no. 2, Jan. 15, 1931, pp. 122–129, 10 figs. Design, construction, and operating characteristics of mechanical and electrical equipment at new Ashtabula station of Cleveland Electric Illuminating Co.; diagrammatic layout of coal-handling equipment; steam, condensate, and feedwater circuit systems; list of principal equipment installed.

**Floating.** Some Facts About S. S. Jacona, A. T. Littlefield. Elec. Light and Power, vol. 9, no. 1, Jan. 1931, pp. 32–34, 8 figs. Large part of energy supplied subsidiaries of New England Public Service Company is from hydro plants, but steam standby is necessitated to ensure continuity of service in time of drought or interruptions to transmission lines; for this reason S. S. Jacona, two-deck freighter of 5128 gross tons was placed in service and is first successful conversion of ship into floating power plant capable of generating 20,000 kw.

**Great Britain.** The Ironbridge Power House, Elec. Times, vol. 79, no. 2046, Jan. 8, 1931, pp. 47–54, 12 figs. Steam conditions are 400 lb. per sq. in. and 800 deg. Fahr. at boiler stop valve; turbine operates at 375 lb. and 750/800 deg. fahr. three Stirling boilers with front wall screens; heating surfaces; boiler, 21,600 sq. ft.; superheater, 7750 sq. ft.; water walls and screens, 3900 sq. ft.; capacity per boiler 270,000 lb. of steam per hr.; steam and water system is described in some detail.

**Operation.** Latest Data on 1250-Lb. Gilbert Station, E. M. Gilbert. Elec. World, vol. 97, no. 2, Jan. 10, 1931, pp. 100–102, 2 figs. Troubles encountered recent unit economy figures, relative costs compared with lower pressure plants and graphs showing that quantity of labor has not been increased due to high pressure; Gilbert plant was built within estimate and for only 7 per cent more than 350 lb. Middleton plant.

**Stand-by.** Shuffleton Plant Emphasizes Steam in the Northwest, W. D. Shannon. Elec. West. vol. 66, no. 1, Jan. 1, 1931, pp. 8–11, 8 figs. Most recent addition to system of Puget Sound Power & Light Co., is 87,500 kv. Shuffleton steam-electric generating station; conceived originally as purely standby plant of 43,750 kva. capacity, relatively poor water conditions of past two years, as far as hydro production is concerned, emphasized desirability of increasing steam-electric generating capacity of system.

### STEAM POWER PLANTS

**Design.** Fortschritte der Waermewirtschaft in 1930 (Progress in Power Plant Efficiency in 1930), Neumann. Brennstoff- und Waermewirtschaft, vol. 12, no. 23–24, Dec. 1–2, 1930, pp. 277–302, 49 figs. Review of improvements in all phases of steam power plant operation with particular regard to Germany; sketches show constructional features of various types of equipment including boilers, traveling grate, air preheater, feedwater apparatus, combustion control devices, etc.

**Great Britain.** New Boiler Plant at Neasden Power Station. Eng. and Boiler House Rev., vol. 44, no. 7, Jan. 1931, pp. 424, 426, 428 and 430, 5 figs. Design, construction, and operating characteristics of boiler plant at Metropolitan Railway Company's power station at Neasden; sectional view through boiler house.

**Heating and Power.** Kombinierte Energiewirtschaft (Combined Heating and Power Systems), E. Schulz. Archiv fuer Waermewirtschaft, vol. 12, no. 1, Jan. 1931, pp. 19–21. Review of reports and papers presented at second World Power Conference in Berlin, June 1930; heat and electric power consumption of different industries; industrial combined heating and power plants; combined heating and power plants in cities; waste-heat utilization.

**High-Pressure.** Operating Experience With Twelve Hundred Pound Pressure Boilers at the Masonite Corporation, E. G. Grady. Combustion, vol. 2, no. 7, Jan. 1931, pp. 47–49, 4 figs. Résumé of operating experience of Masonite Corporation with their 1200 lb. pressure plant; use of high pressure steam to explode wood chips into fiber, process being accomplished without destruction of any of material binders originally present in wood.

**Industrial—Graphic Charts.** Dampf- und Kraft-Erzeugende Nebenbetriebe (Steam- and Power-Generating Auxiliaries), F. Weiss. Waerme, vol. 54, no. 2, Jan. 10, 1931, pp. 23–25, 4 figs. Gantt chart as aid to economic control in industrial plants which generate their own power; basic plans for generation, flow, and consumption of energy; numerical control of energy consumption; total evaluation with aid of Gantt charts.

**Industrial—Iron and Steel Plants.** Trends in the Design of Steel Mill Power Plants, F. H. Daniels. Rolling Mill Jl., vol. 5, no. 1, Jan. 1931, pp. 57–60, 3 figs. By use of central power plants and electric drives, steel industry has effected economies in fuel, maintenance, and general operating expenses; trend in steel industry is toward unit pulverizer system for augmenting blast-furnace gas in firing boilers because of its reliability and operating efficiency.

**Industrial—Petroleum Refineries.** Refinery Waste Supplements Gas at Louisiana Station, J. F. Muir. Power, vol. 73, no. 2, Jan. 13, 1931, pp. 56–59, 4 figs. Neutralized sludge, wax tailings, soda bottoms, and pulverized refinery coke are burned in combination with fuel oil or natural gas under four boilers at plant of Louisiana Steam Products, Inc.; each boiler equipped to burn as many as four different kinds of fuel at one time; boiler furnace design and operation.

**Pulverized-Coal.** Pulverized Fuel Plant at Grimethorpe Colliery. Engineering, vol. 131, no. 3391, Jan. 9, 1931, pp. 39–42, 8 figs. Recent installation at coal mine of Carlton Main Colliery Co. has capacity of 5000 tons of coal per day; its main steam-generating plant consists of 17 Lancashire boilers; extended tests were made of boiler on G. P. F. Burner Company's system of pulverized-fuel firing by pregasification; preliminary tests proved so satisfactory that four of battery of boilers were fitted with system; remaining are hand-fired.

### STEAM TURBINES

**Design.** The Modern A.E.G. Steam Turbine. Power Engr. (Lond.), vol. 26, no. 298, Jan. 1931, pp. 25–30, 10 figs. Design, constructional and operating characteristics of following machines manufactured by Allgemeine Elektrizitats Gesellschaft, A.G., Berlin; power station condensing, geared, back-pressure, extraction, exhaust, and extra-high pressure turbines.

**Operation.** Betriebserfahrungen mit Dampfturbinen grosser Leistung (Operating Experience With High Capacity Steam Turbines), K. Dolzmann. Elektrizitaetswirtschaft, vol. 30, no. 1, Jan. 1931, pp. 1–6, 4 figs. Operating results of 201 turbines of 10,000 kw. capacity and over are analyzed.

### STEEL

**Alloy.** See ALLOY STEELS.

**Embrittlement.** Tension Testing as a Measure of Brittleness, R. L. Geruso. Iron Age, vol. 127, no. 9, Feb. 26, 1931, pp. 692–695, 8 figs. Interpretation of tension tests used in determining elastic limits, proportional limit, yield point, ultimate strength, elongation and reduction of area in its relation to brittleness; graphs illustrate effect of cold working and annealing at different temperatures; reference to principal research work with particular regard to Germany.

**Endurance Testing.** Zur Bestimmung der Dauerstandfestigkeit im Abkuerzungsverfahren (Determination of Endurance by Abbreviated Testing Method), A. Pomp and W. Enders. Stahl und Eisen, vol. 51, no. 6, Feb. 5, 1931, pp. 157–162, 11 figs. Equipment and method for automatic recording of elongation in ratio of 1:1000; maintaining testing temperature constant; relation of speed of dilatation to load at temperatures of 300, 400, and 500 deg. cent. of four carbon steels and at 400 and 500 deg. of steel castings and chromium steel; tests of 4 months' duration; abbreviated method of determining endurance of carbon steels up to temperature of 500 deg.

**Hardening.** Ueber den Mechanismus der Stahlhaertung (Mechanism of Steel Hardening), G. Kurdjumow and G. Sachs. Zeit. fuer Physik, vol. 64, no. 5/6, Aug. 28, 1930, pp. 325–343. 36 figs.; see also Mitteilungen der Deutschen Materialpruefungsanstalten, no. 8, 1930, pp. 70–78, 36 figs. Hardening of carbon steel due to quenching; mechanism of martensite transformation; production of hardened austenite crystals; state of austenite crystal after quenching and annealing; results of X-ray analyses; orientation of crystals in martensite; separation of carbon; nature of steel hardening.

**Heat Treatment—Quenching.** The Selection of Quenching Media. H. J. French Black and White (Metal Edition), vol. 3, no. 4, Jan. 1931, pp. 4–7, 1 fig. Review of principal coolants with respect to cooling rates, permanence of cooling characteristics in use, etc.

**High-Speed.** See HIGH-SPEED STEEL.

**Hot Rolling.** Formanenderungswiderstand und Werkstoffluss beim Walzen (Deformation Resistance and Flow of Material With Rolling), E. Siebel and E. Fangmeier. Stahl und Eisen, vol. 50, no. 51, Dec. 18, 1930, pp. 1769–1775. 8 figs. Relation of deformation resistance to temperature, strength conditions and speed of deformation; strain hardening and recrystallization with hot rolling; upsetting tests according to Hennecke; influence of temperature; comparison of spread formulas. Abstract from Mitteilungen aus dem Kaiser-Wilhelm Institut fuer Eisenforschung, 1930, no. 12, indexed in Engineering Index 1930.

**Stainless, Machining.** The Machining of Stainless Steel. R. Waddell and F. Worton. Machy. (Lond.), vol. 37, no. 952, Jan. 8, 1931, pp. 491–493, 3 figs.; see also Mech. World, vol. 89, nos. 2298 and 2299, Jan. 16, 1930, pp. 58–59 and Jan. 23, pp. 80 and (discussion), 80–82. Brearley steels; Strauss (Krupp) steels; warpage: machining stresses: cold-work hardening of austenitic steels; data for machining operations; milling; cold sawing; drilling and tapping steels. Read before Instn. Production Engrs.

**Stresses, Volume Change With.** Ueber die Volumenaenderung des Stahles bei elastischer und bildsamer Beanspruchung (Volume Change of Steel With Elastic and Plastic Stresses), H. Hanemann and R. Yamada. Archiv fuer das Eisenhuettenwesen, vol. 4, no. 7, Jan. 1931, pp. 353–356, 5 figs. Investigation of short ingot-steel test bars; specific volumes and true stress; volume-flow curve is set up and phenomena occurring with elastic and plastic tensile stress of steel and reactions after tensile stretching are discussed on basis of this curve.

**Temperature Effect.** Creep Stress. K. Gauldie. Engineer, vol. 151, no. 3913, Jan. 9, 1931, p. 54, 3 figs. Letter to editor referring to paper by Baumann, read before Instn. Mech. Engrs., part of which was indexed in Engineering Index 1930, from Nov. 7, 1930, issue of this journal; Baumann's statement that "permissible stress for bolts will depend on time which is required for material to creep to extent equal to elastic deformation under stress applied," is subject to criticism that minimum stress necessary for steam tightness is neglected.

Résistance aux hautes températures des aciers utilisés dans la construction des appareils à vapeur (High Temperature Resistance of Steel for Use in Construction of Steam Equipment), P. Daubresse. Union des Ingénieurs Sortis des Ecoles Speciales de Louvain—Bul. Technique, no. 4, 1930, pp. 3–30, 20 figs. Review of principal research work relating to effect of temperature on physical and strength properties of steel, including work of Georg. Urbanczyk and J. Galibourg.

# T

### TANKS

**Welding.** Electrically-Welded Tanks at a Distillery. Engineer, vol. 151, no. 3917, Feb. 6, 1931, p. 158, 4 figs. Tanks erected by John Thompson (Dudley), Ltd., at large distillery in North of England; plates are continuous throughout from bottom to top, vee butt weld being employed on inside, and welded butt strap on outside; construction not only ensures joint having strength greater than plate itself, but it also improves appearance of structure.

### TENSOMETERS

**Hounsfield.** The Hounsfield Tensometer. Engineering, vol. 131, no. 3393, Jan. 23, 1931, pp. 104–106, 11 figs. Inexpensive portable instrument, although weighing only 20 lb., will test metals up to 100 tons per sq. in., and will give all usual figures, such as yield point, maximum stress, percentage, elongation, and percentage reduction in area, obtainable from tensile tests on large machine, and Brinell hardness in addition.

### THERMODYNAMICS

**Heat of Formation of Water.** The Heat of Formation of Water, F. D. Rossini. U. S. Bur. Standards Jl. Research, vol. 6, no. 1, Jan. 1931, pp. 1–35, 9 figs. Investigation to determine directly quantitative correspondence between energy liberated by reaction of hydrogen and oxygen to form weighed mass of liquid, and measured quantity of electrical energy, using calorimeter as absorber of two quantities of energy and its temperature rise as comparator.

### TRACKLESS TROLLEYS

**Advantages.** Trolley Bus Costs and Advantages Compared With Other Vehicles, E. H. Lamberger. Elec. Traction, vol. 27, no. 1, Jan. 1931, pp. 28–31, 4 figs. Advantages and disadvantages of electric, gas-electric and gas-mechanical buses; curves indicating acceleration characteristics of three types of buses; relative schedule speed characteristics of three types of buses, average engine speed of gas-electric and gas-mechanical vehicles, and power costs; table of comparative investment and operating data between trolley bus, gas-electric and mechanical vehicles.

### TRACTORS

**Agricultural—Testing.** Dynamometer Car for Tractor Trials. Engineering, vol. 131, no. 3390, Jan. 2, 1931, pp. 13–14, 3 figs. Two cars used in testing tractors during International Agricultural-Tractor Trials, carried out near Wallingford; larger consists of chassis on three wheels, front wheel being employed only for stearing, while rear wheels are coupled up through gear box to electric generator; pull on car is measured by means of traction dynamometer, which consists of two parts, link through which tractor pulls car, and recording unit mounted on car.

### TUBES

**Seamless.** Ueber Querwalzverfahren zur Herstellung grosser naht-loser Rohre (Cross-Sectional Rolling Process in Manufacture of Large Seamless Tubes), K. Gruber. Mitteilungen aus dem Kaiser-Wilhelm-Institut fuer Eisenforschung, vol. 12, no. 17, 1930, pp. 285–297, 16 figs. 2.-r.m. Historical review of process; principles underlying calculation; rolling process with regard to friction; approximate determination of forces and energy requirement; tests with cone calibrations.

**Steel.** Fehler bei duennwandigen Rohren infolge Herstellung oder Weiterverarbeitung (Flaws in Thin Wall Tubing Occurring During Manufacture or Subsequent Processing), W. Riede. Roehrenindustrie, vol. 24, nos. 1 and 2, Jan. 1, 1931, pp. 1–3, and Jan. 15, pp. 15–16, 17 figs. Physical properties and composition of mild steel in relation to flaws; microphotographs illustrate crystal structure as criteria for welding quality; soldering and threading of tubes.

### TURBO-GENERATORS

**High-Pressure.** Ein neuer 25,000 kw. Hochdruckdampf-Turbosatz im Kraftwerk Simmering der Wiener Staedtischen Elektrizitaetswerke (New 25,000 kw. High Pressure Turbo Generator in Simmering Plant of Vienna Municipal Electricity Works), R. Mokesch. Elektrotechnik und Maschinenbau, vol. 49, no. 3, Jan. 18, 1931, pp. 43–50, 6 figs. Equipment for 32 atmos., 400 deg. cent. at 3000 r.p.m., is illustrated and described; test results are given.

# V

### VALVES AND VALVE GEARS

**Hydraulic.** Float-Controlled Larner-Johnson Valves for the Sugar Loaf-Rubicon Scheme. Engineering, vol. 131, no. 3390, Jan. 2, 1931, p. 31, 2 figs. In connection with hydroelectric scheme in Victoria, two special valves have been supplied by J. Blakeborough and Sons, intended to supply balancing tanks for compensation water.

**Steam.** Stroemungswiderstand eines Heissdampventils neuer Bauart (Resistance to Flow of Superheater-Steam Valve of Modern Design), C. Pfleiderer and A. Closterhalfen. Archiv fuer Waermewirtschaft und Dampfkesselwesen, vol. 12, no. 1, Jan. 1931, pp. 13–15, 5 figs. Tests to determine flow resistance of new type of valve; low-pressure loss could be accurately measured only with aid of condensate columns; valve gear is known as Freifluss (free-flow) valve.

### VIBRATIONS

**Measurement of.** Neuere Schwingungspruefmaschinen (New Vibration Measuring Machines), W. Spaeth. V.D.I. Zeit., vol. 75, no. 3, Jan. 17, 1931, pp. 83–85, 22 figs. Uses of vibration measuring apparatus; testing of bridges, soil examinations; dynamic investigations of machines, buildings, and aircraft; features of several types of vibration measuring apparatus.

### VISCOSITY

**Tables for Calculating.** Tabelle zur Berechnung der dynamischen Zaehigkeit in Zentipoisen aus den Englergraden (Table for Calculation of Dynamic Viscosity in Centipoises From Engler Degrees), Freund. Petroleum, vol. 26, no. 43, Oct. 22, 1930, pp. 3–4. Table gives dynamic viscosity corresponding with Engler degrees from 1.00 to 8.00 in steps of 0.05 and with specific gravity at temperature of measurement from 0.80 to 1.00 in steps of 0.01.

# W

### WATER PIPE LINES

**Loss of Head in.** Experience sur les conduites de l'usine de Miègebat (Tests of Water Conduits of Miegebat Hydroelectric Plants), G. Camichel, J. Leclerc du Sablon and L. Escande. Bul. Technique de la Suisse Romande, vol. 56, no. 25, Dec. 13, 1930, pp. 303–306. 5 figs. Study with models and actual determinations of loss of head and of Reynolds numbers in piping upstream of turbines.

### WELDED JOINTS

**Design.** Schweissrillen (Welded Joints), H. W. Nies. Autogene Metallbearbeitung, vol. 23, no. 24, Dec. 15, 1930, pp. 381–384, 3 figs. Advantages of welded joints particularly suited to oxyacetylene welding of tubing and cylindrical tanks; sketch illustrates type of flaring or crimping to reduce stresses.

**Testing.** The Strength of Arc-Welded Joints. F. R. Freeman. Instn. Civil Engrs.—Minutes of Proc., no. 4808, vol. 231, pt. 1, 1930–1931, 25 pp., numerous figs. partly on supp. plates. Dorman, Long and Company tests to destruction on full size specimen joints welded under workshop conditions; effect of variation in size and length of fillet, thickness and width of plates joined, etc.; physical properties of plates, weld-metal, and electrodes used; tests of composite joints; "quasi-arc mild steel" electrode used throughout; few tests made with "quasi-arc uranium" electrode; rules for design, working-stresses, etc., of fillet welds and butt welds.

### WELDING

**Boilers.** See BOILERS, Manufacture.

**Tanks.** See TANKS.

### WELDING MACHINES

**Arc.** Making Steel Axle Housings by Arc Welding, J. M. Robinson. Machy. (N. Y.), vol. 37, no. 5, Jan. 1931, pp. 329–330, 3 figs. Method of Oakland Motor Car Co., in producing lightweight rear-axle housings by joining steel stampings on automatic arc-welding machine; data on time requirements, tolerances, and properties of weld.

### WOODWORKING MACHINERY

**Design.** Bau von Holzbearbeitungsmaschinen (Design of Woodworking Machines), O. Schwenninger. V.D.I. Zeit., vol. 75, no. 2, Jan. 10, 1931, pp. 33–40, 28 figs. Progress in design is illustrated by various makes including Kirchner & Co., Leipzig, Meyer & Schwabedissen, Herford, and Aldinger, Stuttgart; data on feeds, speeds, and drive; automatic and semi-automatic operation and principal dimensions; table gives data on feed for various types of wood.

### WOODWORKING PLANTS

**Production Control in.** A Proved Plan for Reducing Material and Labor Costs, H. M. Sutton. Wood Working Industries, vol. 9, no. 1, Jan. 1931, pp. 24–25, and 35, 5 figs. Selection of proper grades of lumber, notes on machine equipment, and suggestions on yard and kiln practice.